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(54) **PATIENT-SPECIFIC ACETABULAR ALIGNMENT GUIDES**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

1,480,285 A 1/1924 Moore
2,181,746 A 11/1939 Siebrandt

(Continued)

FOREIGN PATENT DOCUMENTS

CA 2447694 A1 12/2002
CA 2501041 A1 4/2004

(Continued)

OTHER PUBLICATIONS

“Amazing Precision. Beautiful Results. The next evolution of MAKOplasty® is here,” brochure. (Feb. 2009) MAKO Surgical Corp. 6 pages.

(Continued)

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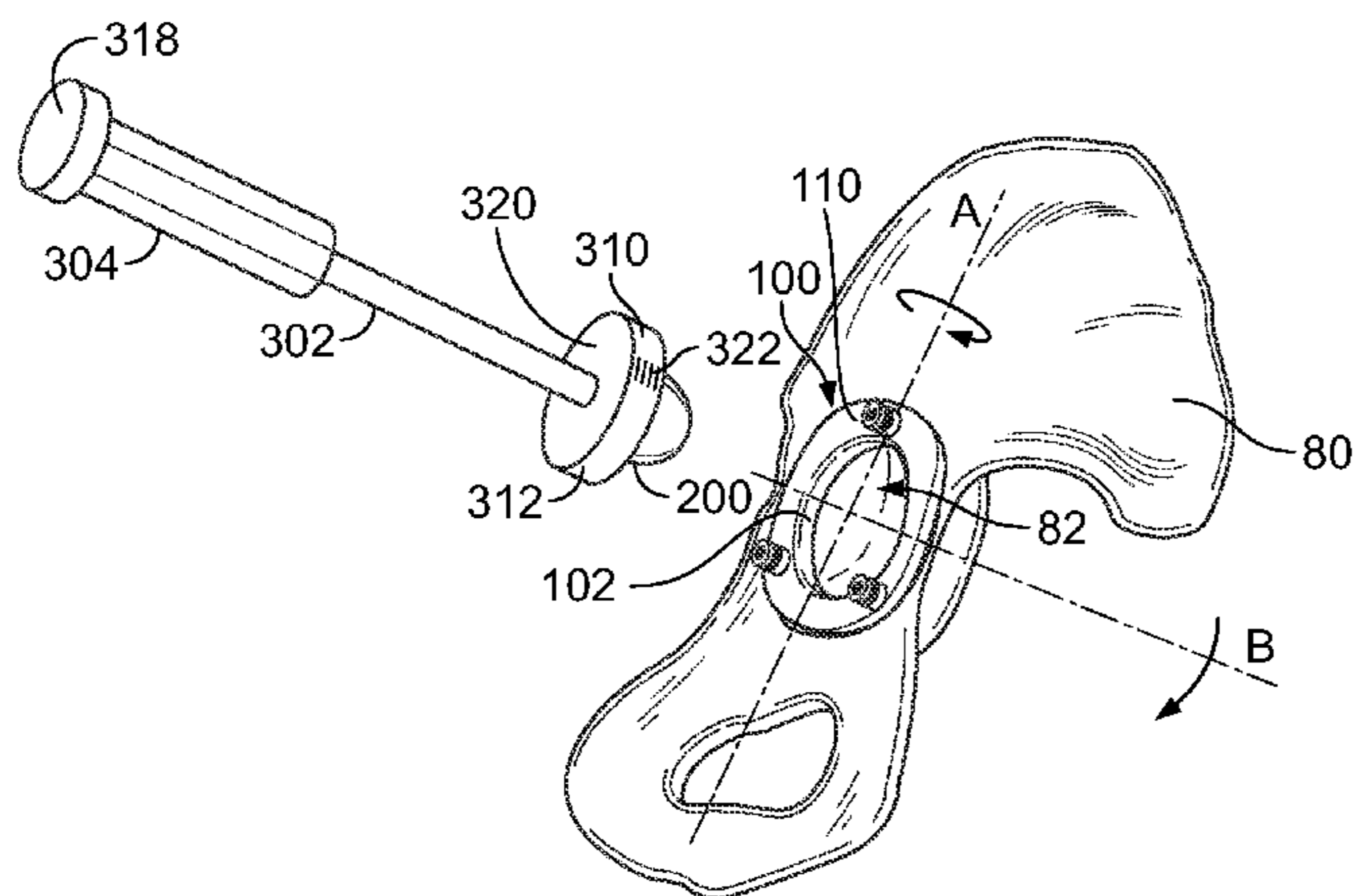
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(57) **ABSTRACT**

An acetabular device includes a patient-specific acetabular alignment guide including a bone engagement surface. The bone engagement surface has a first portion configured and shaped to be conforming and complementary to an acetabular rim surface and a second portion configured and shaped to be conforming and complementary to a periacetabular area of an acetabulum of a patient. The acetabular alignment guide includes a plurality of guiding formations extending through the second portion for guiding a plurality of alignment pins therethrough. The bone engagement surface and the plurality of guiding formations are prepared from a three-dimensional model of the acetabulum of the specific patient reconstructed pre-operatively from a scan of the patient.

17 Claims, 19 Drawing Sheets



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continuation-in-part of application No. 12/973,214, filed on Dec. 20, 2010, which is a continuation-in-part of application No. 12/955,361, filed on Nov. 29, 2010, which is a continuation-in-part of application No. 12/938,913, filed on Nov. 3, 2010, and a continuation-in-part of application No. 12/938,905, filed on Nov. 3, 2010, which is a continuation-in-part of application No. 12/893,306, filed on Sep. 29, 2010, which is a continuation-in-part of application No. 12/888,005, filed on Sep. 22, 2010, now Pat. No. 8,377,066, which is a continuation-in-part of application No. 12/714,023, filed on Feb. 26, 2010, now Pat. No. 8,241,293, which is a continuation-in-part of application No. 12/571,969, filed on Oct. 1, 2009, which is a continuation-in-part of application No. 12/486,992, filed on Jun. 18, 2009, and a continuation-in-part of application No. 12/389,901, filed on Feb. 20, 2009, now Pat. No. 8,133,234, which is a continuation-in-part of application No. 12/211,407, filed on Sep. 16, 2008, which is a continuation-in-part of application No. 12/039,849, filed on Feb. 29, 2008, now Pat. No. 8,282,646, and a continuation-in-part of application No. 11/756,057, filed on May 31, 2007, now Pat. No. 8,092,465, said application No. 12/039,849 is a continuation-in-part of application No. 11/971,390, filed on Jan. 9, 2008, now Pat. No. 8,070,752, which is a continuation-in-part of application No. 11/363,548, filed on Feb. 27, 2006, now Pat. No. 7,780,672, said application No. 12/039,849 is a continuation-in-part of application No. 12/025,414, filed on Feb. 4, 2008, now Pat. No. 8,298,237, said application No. 13/111,007 is a continuation-in-part of application No. 12/872,663, filed on Aug. 31, 2010, now Pat. No. 8,407,067, said application No. 13/111,007 is a continuation-in-part of application No. 12/483,807, filed on Jun. 12, 2009, now Pat. No. 8,473,305, which is a continuation-in-part of application No. 12/371,096, filed on Feb. 13, 2009, which is a continuation-in-part of application No. 12/103,824, filed on Apr. 16, 2008, now abandoned, said application No. 13/111,007 is a continuation-in-part of application No. 12/103,834, filed on Apr. 16, 2008, now Pat. No. 7,967,868.

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References Cited

U.S. PATENT DOCUMENTS

2,407,845 A 9/1946 Nemeyer
 2,618,913 A 11/1952 Plancon et al.
 2,910,978 A 11/1959 Urist
 3,840,904 A 10/1974 Tronzo
 4,246,895 A 1/1981 Rehder

4,306,866 A 12/1981 Weissman
 4,324,006 A 4/1982 Charnley
 4,421,112 A 12/1983 Mains et al.
 4,436,684 A 3/1984 White
 4,475,549 A 10/1984 Oh
 4,506,393 A 3/1985 Murphy
 4,524,766 A 6/1985 Petersen
 4,528,980 A * 7/1985 Kenna 606/80
 4,619,658 A 10/1986 Pappas et al.
 4,621,630 A 11/1986 Kenna
 4,632,111 A 12/1986 Roche
 4,633,862 A 1/1987 Petersen
 4,663,720 A 5/1987 Duret et al.
 4,695,283 A 9/1987 Aldinger
 4,696,292 A 9/1987 Heiple
 4,703,751 A 11/1987 Pohl
 4,704,686 A 11/1987 Aldinger
 4,719,907 A 1/1988 Banko et al.
 4,721,104 A 1/1988 Kaufman et al.
 4,722,330 A 2/1988 Russell et al.
 4,778,474 A 10/1988 Homsy
 4,800,874 A 1/1989 David et al.
 4,821,213 A 4/1989 Cline et al.
 4,822,365 A 4/1989 Walker et al.
 4,841,975 A 6/1989 Woolson
 4,846,161 A 7/1989 Roger
 4,871,975 A 10/1989 Nawata et al.
 4,893,619 A 1/1990 Dale et al.
 4,896,663 A 1/1990 Vandewalls
 4,927,422 A 5/1990 Engelhardt
 4,936,862 A 6/1990 Walker et al.
 4,952,213 A 8/1990 Bowman et al.
 4,959,066 A 9/1990 Dunn et al.
 4,976,737 A 12/1990 Leake
 4,979,949 A 12/1990 Matsen, III et al.
 4,985,037 A 1/1991 Petersen
 5,002,579 A 3/1991 Copf et al.
 5,007,936 A 4/1991 Woolson
 5,019,105 A 5/1991 Wiley
 5,030,221 A 7/1991 Buechel et al.
 5,041,117 A 8/1991 Engelhardt
 5,053,037 A 10/1991 Lackey
 5,053,039 A 10/1991 Hofmann et al.
 5,086,401 A 2/1992 Glassman et al.
 5,098,383 A 3/1992 Hemmy et al.
 5,098,436 A 3/1992 Ferrante et al.
 5,108,425 A 4/1992 Hwang
 5,122,144 A 6/1992 Bert et al.
 5,129,908 A 7/1992 Petersen
 5,129,909 A 7/1992 Sutherland
 5,133,760 A 7/1992 Petersen et al.
 5,140,777 A 8/1992 Ushiyama et al.
 5,150,304 A 9/1992 Berchem et al.
 5,176,684 A 1/1993 Ferrante et al.
 5,176,711 A 1/1993 Grimes
 5,246,444 A 9/1993 Schreiber
 5,258,032 A 11/1993 Bertin
 5,261,915 A 11/1993 Durlacher et al.
 5,274,565 A 12/1993 Reuben
 5,299,288 A 3/1994 Glassman et al.
 5,300,077 A 4/1994 Howell
 5,320,625 A 6/1994 Bertin
 5,342,366 A 8/1994 Whiteside et al.
 5,344,423 A 9/1994 Dietz et al.
 5,360,446 A 11/1994 Kennedy
 5,364,402 A 11/1994 Mumme et al.
 5,368,858 A 11/1994 Hunziker
 5,370,692 A 12/1994 Fink et al.
 5,370,699 A 12/1994 Hood et al.
 5,405,395 A 4/1995 Coates
 5,408,409 A 4/1995 Glassman et al.
 5,415,662 A 5/1995 Ferrante et al.
 5,417,694 A 5/1995 Marik et al.
 5,438,263 A 8/1995 Dworkin et al.
 5,440,496 A 8/1995 Andersson et al.
 5,448,489 A 9/1995 Reuben
 5,449,360 A 9/1995 Schreiber
 5,452,407 A 9/1995 Crook
 5,454,816 A 10/1995 Ashby

US 8,603,180 B2

5,472,415 A	12/1995	King et al.	6,206,927 B1	3/2001	Fell et al.
5,474,559 A	12/1995	Bertin et al.	6,254,604 B1	7/2001	Howell
5,490,854 A	2/1996	Fisher et al.	6,258,097 B1	7/2001	Cook et al.
5,496,324 A	3/1996	Barnes	6,264,698 B1	7/2001	Lawes et al.
5,507,833 A	4/1996	Bohn	6,273,891 B1	8/2001	Masini
5,514,519 A	5/1996	Neckers	6,290,727 B1	9/2001	Otto et al.
5,520,695 A	5/1996	Luckman	6,293,971 B1	9/2001	Nelson et al.
5,527,317 A	6/1996	Ashby et al.	6,312,258 B1	11/2001	Ashman
5,539,649 A	7/1996	Walsh et al.	6,312,473 B1	11/2001	Oshida
5,540,695 A	7/1996	Levy	6,319,285 B1	11/2001	Chamier et al.
5,549,688 A	8/1996	Ries et al.	6,325,829 B1	12/2001	Schmotzer
5,554,190 A	9/1996	Draenert	6,343,987 B2	2/2002	Hayama et al.
5,560,096 A	10/1996	Stephens	6,354,011 B1	3/2002	Albrecht
5,571,110 A	11/1996	Matsen, III et al.	6,379,299 B1	4/2002	Borodulin et al.
5,578,037 A	11/1996	Sanders et al.	6,383,228 B1	5/2002	Schmotzer
5,595,703 A	1/1997	Swaelens et al.	6,391,251 B1	5/2002	Keicher et al.
5,607,431 A	3/1997	Dudasik et al.	6,395,005 B1	5/2002	Lovell
5,613,969 A	3/1997	Jenkins, Jr.	6,416,553 B1	7/2002	White et al.
5,620,448 A	4/1997	Puddu	6,427,698 B1	8/2002	Yoon
5,634,927 A	6/1997	Houston et al.	6,459,948 B1	10/2002	Ateshian et al.
5,641,323 A	6/1997	Caldarise	6,463,351 B1	10/2002	Clynch
5,658,294 A	8/1997	Sederholm	6,475,243 B1	11/2002	Sheldon et al.
5,662,656 A	9/1997	White	6,482,236 B2	11/2002	Habecker
5,671,018 A	9/1997	Ohara et al.	6,488,715 B1	12/2002	Pope et al.
5,677,107 A	10/1997	Neckers	6,503,255 B1	1/2003	Albrektsson et al.
5,681,354 A	10/1997	Eckhoff	6,510,334 B1	1/2003	Schuster et al.
5,682,886 A	11/1997	Delp et al.	6,514,259 B2	2/2003	Picard et al.
5,690,635 A	11/1997	Matsen, III et al.	6,517,583 B1	2/2003	Pope et al.
5,702,460 A	12/1997	Carls et al.	6,520,964 B2	2/2003	Tallarida et al.
5,704,941 A	1/1998	Jacobson et al.	6,533,737 B1	3/2003	Brosseau et al.
5,722,978 A	3/1998	Jenkins, Jr.	6,547,823 B2	4/2003	Scarborough et al.
5,725,376 A	3/1998	Poirier	6,554,837 B1	4/2003	Hauri et al.
5,725,593 A	3/1998	Caracciolo	6,556,008 B2	4/2003	Thesen
5,735,277 A	4/1998	Schuster	6,558,391 B2	5/2003	Axelsson, Jr. et al.
5,748,767 A	5/1998	Raab	6,558,428 B2	5/2003	Park
5,749,875 A	5/1998	Puddu	6,564,085 B2	5/2003	Meaney et al.
5,749,876 A	5/1998	Duvillier et al.	6,567,681 B1	5/2003	Lindequist
5,762,125 A	6/1998	Mastrorio	6,575,980 B1	6/2003	Robie et al.
5,768,134 A	6/1998	Swaelens et al.	6,575,982 B1	6/2003	Bonutti
5,769,092 A	6/1998	Williamson, Jr.	6,591,581 B2	7/2003	Schmieding
5,786,217 A	7/1998	Tube et al.	6,605,293 B1	8/2003	Giordano et al.
5,792,143 A	8/1998	Samuelson et al.	6,622,567 B1	9/2003	Hamel et al.
5,798,924 A	8/1998	Eufinger et al.	6,629,999 B1	10/2003	Serafin, Jr.
5,799,055 A	8/1998	Peshkin et al.	6,641,617 B1	11/2003	Merrill et al.
5,860,981 A	1/1999	Bertin et al.	6,682,566 B2	1/2004	Draenert
5,871,018 A	2/1999	Delp et al.	6,682,567 B1	1/2004	Schroeder
5,876,456 A	3/1999	Sederholm et al.	6,696,073 B2	2/2004	Boyce et al.
5,879,398 A	3/1999	Swarts et al.	6,697,664 B2	2/2004	Kienzle, III et al.
5,879,402 A	3/1999	Lawes et al.	6,701,174 B1	3/2004	Krause et al.
5,879,404 A	3/1999	Bateman et al.	6,709,462 B2	3/2004	Hanssen
5,880,976 A	3/1999	DiGioia, III et al.	6,711,431 B2	3/2004	Sarin et al.
5,885,297 A	3/1999	Matsen, III	6,711,432 B1	3/2004	Krause et al.
5,885,298 A	3/1999	Herrington et al.	6,712,856 B1	3/2004	Carignan et al.
5,895,389 A	4/1999	Schenk et al.	6,716,249 B2	4/2004	Hyde
5,899,907 A	5/1999	Johnson	6,725,077 B1	4/2004	Balloni et al.
5,901,060 A	5/1999	Schall et al.	6,738,657 B1	5/2004	Franklin et al.
5,911,724 A	6/1999	Wehrli	6,740,092 B2	5/2004	Lombardo et al.
5,921,988 A	7/1999	Legrand	6,749,638 B1	6/2004	Saladino
5,925,049 A	7/1999	Gustilo et al.	6,750,653 B1	6/2004	Zou et al.
5,925,077 A	7/1999	Williamson et al.	6,772,026 B2	8/2004	Bradbury et al.
5,942,370 A	8/1999	Neckers	6,780,190 B2	8/2004	Maroney
5,967,777 A	10/1999	Klein et al.	6,786,930 B2	9/2004	Biscup
5,976,149 A	11/1999	Masini	6,799,066 B2	9/2004	Steines et al.
5,980,526 A	11/1999	Johnson et al.	6,823,871 B2	11/2004	Schmieding
6,033,415 A	3/2000	Mittelstadt et al.	6,827,723 B2	12/2004	Carson
6,059,789 A	5/2000	Dinger et al.	6,887,247 B1	5/2005	Couture et al.
6,059,833 A	5/2000	Doets	6,905,514 B2	6/2005	Carignan et al.
6,086,593 A	7/2000	Bonutti	6,923,817 B2	8/2005	Carson et al.
6,120,510 A	9/2000	Albrektsson et al.	6,923,831 B2	8/2005	Fell et al.
6,120,544 A	9/2000	Grundeil et al.	6,932,842 B1	8/2005	Litschko et al.
6,126,690 A	10/2000	Ateshian et al.	6,942,475 B2	9/2005	Ensign et al.
6,132,469 A	10/2000	Schroeder	6,944,518 B2	9/2005	Roose
6,136,033 A	10/2000	Suemer	6,945,976 B2	9/2005	Ball et al.
6,156,069 A	12/2000	Amstutz	6,953,480 B2	10/2005	Mears et al.
6,161,080 A	12/2000	Aouni-Ateshian et al.	6,960,216 B2	11/2005	Kolb et al.
6,187,010 B1	2/2001	Masini	6,966,932 B1	11/2005	Schroeder
6,195,615 B1	2/2001	Lysen	6,990,220 B2	1/2006	Ellis et al.
6,203,546 B1	3/2001	MacMahon	7,029,479 B2	4/2006	Tallarida et al.
6,205,411 B1	3/2001	DiGioia, III et al.	7,042,222 B2	5/2006	Zheng et al.

US 8,603,180 B2

7,048,741 B2	5/2006	Swanson	7,962,196 B2	6/2011	Tuma
7,050,877 B2	5/2006	Iseki et al.	7,963,968 B2	6/2011	Dees, Jr.
7,060,074 B2	6/2006	Rosa et al.	7,967,823 B2	6/2011	Ammann et al.
7,074,241 B2	7/2006	McKinnon	7,967,868 B2	6/2011	White et al.
RE39,301 E	9/2006	Bertin	7,974,677 B2	7/2011	Mire et al.
7,104,997 B2	9/2006	Lionberger et al.	7,981,158 B2	7/2011	Fitz et al.
7,105,026 B2	9/2006	Johnson et al.	7,993,353 B2	8/2011	Rossner et al.
7,115,131 B2	10/2006	Engl et al.	8,062,301 B2	11/2011	Ammann et al.
7,121,832 B2	10/2006	Hsieh et al.	8,070,752 B2	12/2011	Metzger et al.
7,141,053 B2	11/2006	Rosa et al.	8,083,745 B2	12/2011	Lang et al.
7,169,185 B2	1/2007	Sidebotham	8,083,746 B2	12/2011	Novak
7,176,466 B2	2/2007	Rouso et al.	8,083,749 B2	12/2011	Taber
7,184,814 B2	2/2007	Lang et al.	8,086,336 B2	12/2011	Christensen
7,198,628 B2	4/2007	Ondrla et al.	8,092,465 B2	1/2012	Metzger et al.
7,218,232 B2	5/2007	DiSilvestro et al.	8,133,230 B2	3/2012	Stevens et al.
7,220,264 B1	5/2007	Hershberger	8,133,234 B2	3/2012	Meridew et al.
7,239,908 B1	7/2007	Alexander et al.	8,137,406 B2	3/2012	Novak et al.
7,241,315 B2	7/2007	Evans	8,167,951 B2	5/2012	Ammann et al.
7,255,702 B2	8/2007	Serra et al.	8,170,641 B2	5/2012	Belcher
7,258,701 B2	8/2007	Aram et al.	8,182,489 B2	5/2012	Horacek
7,275,218 B2	9/2007	Petrella et al.	8,192,441 B2	6/2012	Collazo
7,282,054 B2	10/2007	Steffensmeier et al.	8,192,495 B2	6/2012	Simpson et al.
7,294,133 B2	11/2007	Zink et al.	8,211,112 B2	7/2012	Novak et al.
7,297,164 B2	11/2007	Johnson et al.	8,241,292 B2	8/2012	Collazo
7,309,339 B2	12/2007	Cusick et al.	8,241,293 B2	8/2012	Stone et al.
7,333,013 B2	2/2008	Berger	8,265,790 B2	9/2012	Amiot et al.
7,335,207 B1	2/2008	Smith	8,282,646 B2	10/2012	Schoenefeld et al.
7,335,231 B2	2/2008	McLean	8,298,237 B2	10/2012	Schoenefeld et al.
7,371,260 B2	5/2008	Malinin	8,303,596 B2	11/2012	Plafky et al.
7,383,164 B2	6/2008	Aram et al.	8,333,772 B2	12/2012	Fox et al.
7,385,498 B2	6/2008	Dobosz	8,355,773 B2	1/2013	Leitner et al.
7,388,972 B2	6/2008	Kitson	2001/0005797 A1	6/2001	Barlow et al.
7,392,076 B2	6/2008	Moctezuma de La Barrera	2001/0011190 A1	8/2001	Park
7,427,200 B2	9/2008	Noble et al.	2001/0054478 A1	12/2001	Watanabe et al.
7,427,272 B2	9/2008	Richard et al.	2002/0007294 A1	1/2002	Bradbury et al.
7,468,075 B2	12/2008	Lang et al.	2002/0029045 A1	3/2002	Bonutti
7,474,223 B2	1/2009	Nycz et al.	2002/0052606 A1	5/2002	Bonutti
7,488,325 B2	2/2009	Qian	2002/0059049 A1	5/2002	Bradbury et al.
7,494,510 B2	2/2009	Zweymuller	2002/0082741 A1	6/2002	Mazumder et al.
7,517,365 B2	4/2009	Carignan et al.	2002/0087274 A1	7/2002	Alexander et al.
7,527,631 B2	5/2009	Maroney et al.	2002/0107522 A1	8/2002	Picard et al.
7,534,263 B2	5/2009	Burdulis, Jr. et al.	2002/0120342 A1	8/2002	Gibbs
7,542,791 B2	6/2009	Mire et al.	2002/0128872 A1	9/2002	Giammattei
7,559,931 B2	7/2009	Stone	2002/0147415 A1	10/2002	Martelli
7,575,602 B2	8/2009	Amirouche et al.	2003/0009171 A1	1/2003	Tornier
7,578,851 B2	8/2009	Dong et al.	2003/0009234 A1	1/2003	Treacy et al.
7,582,091 B2	9/2009	Duncan et al.	2003/0011624 A1	1/2003	Ellis
7,591,821 B2	9/2009	Kelman	2003/0018338 A1	1/2003	Axelson et al.
7,601,155 B2	10/2009	Petersen	2003/0039676 A1	2/2003	Boyce et al.
7,604,639 B2	10/2009	Swanson	2003/0055502 A1	3/2003	Lang et al.
7,611,516 B2	11/2009	Maroney	2003/0105526 A1	6/2003	Bryant et al.
7,618,451 B2	11/2009	Berez et al.	2003/0109784 A1	6/2003	Loh et al.
7,621,915 B2	11/2009	Frederick et al.	2003/0120276 A1	6/2003	Tallarida et al.
7,625,409 B2	12/2009	Saltzman et al.	2003/0130741 A1*	7/2003	McMinn 623/23.14
7,646,161 B2	1/2010	Albu-Schaffer et al.	2003/0139817 A1	7/2003	Tuke et al.
7,651,501 B2	1/2010	Penenberg et al.	2003/0158606 A1	8/2003	Coon et al.
7,670,345 B2	3/2010	Plassky et al.	2003/0171757 A1	9/2003	Coon et al.
7,682,398 B2	3/2010	Croxton et al.	2003/0212459 A1	11/2003	Gibbs
7,695,477 B2	4/2010	Creger et al.	2003/0216669 A1	11/2003	Lang et al.
7,695,521 B2	4/2010	Ely et al.	2004/0018144 A1	1/2004	Briscoe
7,699,847 B2	4/2010	Sheldon et al.	2004/0030245 A1	2/2004	Noble et al.
7,704,253 B2	4/2010	Bastian et al.	2004/0054372 A1	3/2004	Corden et al.
7,723,395 B2	5/2010	Ringeisen et al.	2004/0068187 A1	4/2004	Krause et al.
7,780,672 B2	8/2010	Metzger et al.	2004/0092932 A1	5/2004	Aubin et al.
7,780,740 B2	8/2010	Steinberg	2004/0098133 A1	5/2004	Carignan et al.
7,794,466 B2	9/2010	Merchant et al.	2004/0102852 A1	5/2004	Johnson et al.
7,794,467 B2	9/2010	McGinley et al.	2004/0102866 A1	5/2004	Harris et al.
7,794,504 B2	9/2010	Case	2004/0106926 A1	6/2004	Leitner et al.
7,806,896 B1	10/2010	Bonutti	2004/0115586 A1	6/2004	Andreiko et al.
7,809,184 B2	10/2010	Neubauer et al.	2004/0122439 A1	6/2004	Dwyer et al.
7,819,925 B2	10/2010	King et al.	2004/0128026 A1	7/2004	Harris et al.
7,828,806 B2	11/2010	Graf et al.	2004/0133276 A1	7/2004	Lang et al.
7,879,109 B2	2/2011	Borden et al.	2004/0138754 A1	7/2004	Lang et al.
7,892,261 B2	2/2011	Bonutti	2004/0143336 A1	7/2004	Burkinshaw
7,896,921 B2	3/2011	Smith et al.	2004/0147927 A1	7/2004	Tsougarakis et al.
7,935,119 B2	5/2011	Ammann et al.	2004/0148026 A1	7/2004	Bonutti
7,935,150 B2	5/2011	Carignan et al.	2004/0153079 A1	8/2004	Tsougarakis et al.
7,938,861 B2	5/2011	King et al.	2004/0153087 A1	8/2004	Sanford et al.
7,959,637 B2	6/2011	Fox et al.	2004/0158254 A1	8/2004	Eisermann

US 8,603,180 B2

2004/0162619	A1	8/2004	Blaylock et al.	2006/0142657	A1	6/2006	Quaid et al.
2004/0167390	A1	8/2004	Alexander et al.	2006/0155380	A1	7/2006	Clemow et al.
2004/0171924	A1	9/2004	Mire et al.	2006/0161167	A1	7/2006	Myers et al.
2004/0172137	A1	9/2004	Blaylock et al.	2006/0172263	A1	8/2006	Quadling et al.
2004/0181144	A1	9/2004	Cinquin et al.	2006/0178497	A1	8/2006	Gevaert et al.
2004/0204644	A1	10/2004	Tsougarakis et al.	2006/0184177	A1	8/2006	Echeverri
2004/0204760	A1	10/2004	Fitz et al.	2006/0184250	A1	8/2006	Bandoh et al.
2004/0212586	A1	10/2004	Denny	2006/0190086	A1	8/2006	Clemow et al.
2004/0220583	A1	11/2004	Pieczynski et al.	2006/0195111	A1	8/2006	Couture
2004/0225369	A1	11/2004	Lakin et al.	2006/0195194	A1	8/2006	Gunther
2004/0236341	A1	11/2004	Petersen	2006/0195198	A1	8/2006	James
2004/0236424	A1	11/2004	Berez et al.	2006/0198943	A1	9/2006	Kumar
2004/0243481	A1	12/2004	Bradbury et al.	2006/0200158	A1	9/2006	Farling et al.
2004/0254584	A1	12/2004	Sarin et al.	2006/0204932	A1	9/2006	Haymann et al.
2004/0260301	A1	12/2004	Lionberger et al.	2006/0210644	A1	9/2006	Levin
2005/0008887	A1	1/2005	Haymann et al.	2006/0217808	A1	9/2006	Novak et al.
2005/0010227	A1	1/2005	Paul	2006/0235421	A1	10/2006	Rosa et al.
2005/0010300	A1	1/2005	Disilvestro et al.	2006/0241635	A1	10/2006	Stumpo et al.
2005/0015022	A1	1/2005	Richard et al.	2006/0241636	A1	10/2006	Novak et al.
2005/0019664	A1	1/2005	Matsumoto	2006/0271058	A1	11/2006	Ashton et al.
2005/0021148	A1	1/2005	Gibbs	2006/0276796	A1	12/2006	Creger et al.
2005/0027303	A1	2/2005	Lionberger et al.	2006/0276797	A1	12/2006	Botimer
2005/0027361	A1	2/2005	Reiley	2006/0287733	A1	12/2006	Bonutti
2005/0043806	A1	2/2005	Cook et al.	2006/0293681	A1	12/2006	Claypool et al.
2005/0043837	A1	2/2005	Rubbert et al.	2007/0015995	A1	1/2007	Lang et al.
2005/0049524	A1	3/2005	Lefevre et al.	2007/0016209	A1	1/2007	Ammann et al.
2005/0049603	A1	3/2005	Calton et al.	2007/0027680	A1	2/2007	Ashley et al.
2005/0059873	A1	3/2005	Glozman et al.	2007/0066917	A1	3/2007	Hodorek et al.
2005/0060040	A1	3/2005	Auxepaules et al.	2007/0073137	A1	3/2007	Schoenefeld
2005/0065628	A1	3/2005	Roose	2007/0083214	A1	4/2007	Duncan et al.
2005/0070897	A1	3/2005	Petersen	2007/0083266	A1	4/2007	Lang
2005/0071015	A1	3/2005	Sekel	2007/0100258	A1	5/2007	Shoham et al.
2005/0075641	A1	4/2005	Singhatat et al.	2007/0100450	A1	5/2007	Hodorek
2005/0096535	A1	5/2005	de la Barrera	2007/0100462	A1	5/2007	Lang et al.
2005/0113841	A1	5/2005	Sheldon et al.	2007/0106391	A1	5/2007	Ronk
2005/0113846	A1	5/2005	Carson	2007/0118055	A1	5/2007	McCombs
2005/0119664	A1	6/2005	Carignan et al.	2007/0118138	A1	5/2007	Seo et al.
2005/0131662	A1	6/2005	Ascenzi et al.	2007/0118243	A1	5/2007	Schroeder et al.
2005/0137708	A1	6/2005	Clark	2007/0150068	A1	6/2007	Dong et al.
2005/0148843	A1	7/2005	Roose	2007/0156066	A1	7/2007	McGinley et al.
2005/0149042	A1	7/2005	Metzger	2007/0156171	A1	7/2007	Lang et al.
2005/0171545	A1	8/2005	Walsh et al.	2007/0162038	A1	7/2007	Tuke
2005/0177245	A1	8/2005	Leatherbury et al.	2007/0162039	A1	7/2007	Wozencroft
2005/0203536	A1	9/2005	Laffargue et al.	2007/0173946	A1	7/2007	Bonutti
2005/0203540	A1	9/2005	Broyles	2007/0173948	A1	7/2007	Meridew et al.
2005/0216305	A1	9/2005	Funderud	2007/0185498	A2	8/2007	Lavallee
2005/0222573	A1	10/2005	Branch et al.	2007/0191962	A1	8/2007	Jones et al.
2005/0228393	A1	10/2005	Williams et al.	2007/0198022	A1	8/2007	Lang et al.
2005/0234461	A1	10/2005	Burdulis et al.	2007/0203430	A1	8/2007	Lang et al.
2005/0234465	A1	10/2005	McCombs et al.	2007/0203583	A1	8/2007	Slone
2005/0234468	A1	10/2005	Carson	2007/0203605	A1	8/2007	Melton et al.
2005/0240195	A1	10/2005	Axelsson et al.	2007/0219562	A1	9/2007	Slone et al.
2005/0240267	A1	10/2005	Randall et al.	2007/0219639	A1	9/2007	Otto et al.
2005/0244239	A1	11/2005	Shimp	2007/0219640	A1	9/2007	Steinberg
2005/0245934	A1	11/2005	Tuke et al.	2007/0224238	A1	9/2007	Mansmann et al.
2005/0245936	A1	11/2005	Tuke et al.	2007/0226986	A1	10/2007	Park et al.
2005/0251147	A1	11/2005	Novak	2007/0233121	A1	10/2007	Carson et al.
2005/0267353	A1	12/2005	Marquart et al.	2007/0233136	A1	10/2007	Wozencroft
2005/0267485	A1	12/2005	Cordes et al.	2007/0233140	A1	10/2007	Metzger et al.
2005/0267584	A1	12/2005	Burdulis et al.	2007/0233141	A1	10/2007	Park et al.
2005/0273114	A1	12/2005	Novak	2007/0233269	A1	10/2007	Steines et al.
2005/0283252	A1	12/2005	Coon et al.	2007/0233272	A1	10/2007	Boyce et al.
2005/0283253	A1	12/2005	Coon et al.	2007/0238069	A1	10/2007	Lovald et al.
2006/0004284	A1	1/2006	Grunschlager et al.	2007/0239282	A1	10/2007	Caylor et al.
2006/0015120	A1	1/2006	Richard et al.	2007/0239481	A1	10/2007	DiSilvestro et al.
2006/0030853	A1	2/2006	Haines	2007/0244487	A1	10/2007	Ammann et al.
2006/0038520	A1	2/2006	Negoro et al.	2007/0250169	A1	10/2007	Lang
2006/0052725	A1	3/2006	Santilli	2007/0250175	A1	10/2007	Meridew et al.
2006/0058803	A1	3/2006	Cuckler et al.	2007/0253617	A1	11/2007	Arata et al.
2006/0058884	A1	3/2006	Aram et al.	2007/0255288	A1	11/2007	Mahfouz et al.
2006/0058886	A1	3/2006	Wozencroft	2007/0255412	A1	11/2007	Hajaj et al.
2006/0089621	A1	4/2006	Fard	2007/0262867	A1	11/2007	Westrick et al.
2006/0093988	A1	5/2006	Swaelens et al.	2007/0272747	A1	11/2007	Woods et al.
2006/0094951	A1	5/2006	Dean et al.	2007/0276224	A1	11/2007	Lang et al.
2006/0095044	A1	5/2006	Grady et al.	2007/0276400	A1	11/2007	Moore et al.
2006/0100832	A1	5/2006	Bowman	2007/0276501	A1	11/2007	Betz et al.
2006/0111722	A1	5/2006	Bouadi	2007/0288029	A1	12/2007	Justin et al.
2006/0122616	A1	6/2006	Bennett et al.	2007/0288030	A1	12/2007	Metzger et al.
2006/0136058	A1	6/2006	Pietrzak	2008/0009874	A1	1/2008	Meridew et al.

2008/0009952	A1	1/2008	Hodge	2009/0088759	A1	4/2009	Aram et al.
2008/0015599	A1	1/2008	D'Alessio et al.	2009/0088760	A1	4/2009	Aram et al.
2008/0015603	A1	1/2008	Collazo	2009/0088761	A1	4/2009	Roose et al.
2008/0015604	A1	1/2008	Collazo	2009/0088763	A1	4/2009	Aram et al.
2008/0015605	A1	1/2008	Collazo	2009/0088865	A1	4/2009	Brehm
2008/0021299	A1	1/2008	Meulink	2009/0088866	A1	4/2009	Case
2008/0021494	A1	1/2008	Schmelzeisen-Redeker et al.	2009/0089034	A1	4/2009	Penney et al.
2008/0021567	A1	1/2008	Meulink et al.	2009/0089081	A1	4/2009	Haddad
2008/0027563	A1	1/2008	Johnson et al.	2009/0093815	A1	4/2009	Fletcher et al.
2008/0033442	A1	2/2008	Amiot et al.	2009/0093816	A1	4/2009	Roose et al.
2008/0039850	A1	2/2008	Rowley et al.	2009/0096613	A1	4/2009	Westrick
2008/0051799	A1	2/2008	Bonutti	2009/0099567	A1	4/2009	Zajac
2008/0051910	A1	2/2008	Kammerzell et al.	2009/0105837	A1	4/2009	Lafosse et al.
2008/0058945	A1	3/2008	Hajaj et al.	2009/0118736	A1	5/2009	Kreuzer
2008/0058947	A1	3/2008	Earl et al.	2009/0118769	A1	5/2009	Sixto, Jr. et al.
2008/0062183	A1	3/2008	Swaelens	2009/0131941	A1	5/2009	Park et al.
2008/0065225	A1	3/2008	Wasielewski et al.	2009/0131942	A1	5/2009	Aker et al.
2008/0097451	A1	4/2008	Chen et al.	2009/0138020	A1	5/2009	Park et al.
2008/0112996	A1	5/2008	Harlow et al.	2009/0149965	A1	6/2009	Quaid
2008/0114370	A1	5/2008	Schoenefeld	2009/0149977	A1	6/2009	Schendel
2008/0133022	A1	6/2008	Caylor	2009/0151736	A1	6/2009	Belcher et al.
2008/0140081	A1	6/2008	Heavener et al.	2009/0157083	A1	6/2009	Park et al.
2008/0140209	A1	6/2008	Iannotti et al.	2009/0163922	A1	6/2009	Meridew et al.
2008/0140213	A1	6/2008	Ammann et al.	2009/0163923	A1	6/2009	Flett et al.
2008/0146969	A1	6/2008	Kurtz	2009/0164024	A1	6/2009	Rudan et al.
2008/0147072	A1	6/2008	Park et al.	2009/0177282	A1	7/2009	Bureau et al.
2008/0147073	A1	6/2008	Ammann et al.	2009/0187193	A1	7/2009	Maroney et al.
2008/0161815	A1	7/2008	Schoenefeld et al.	2009/0204225	A1	8/2009	Meridew et al.
2008/0161816	A1	7/2008	Stevens et al.	2009/0209884	A1	8/2009	Van Vorhis et al.
2008/0172125	A1	7/2008	Ek	2009/0209961	A1	8/2009	Ferrante et al.
2008/0195099	A1	8/2008	Minas	2009/0210067	A1	8/2009	Meridew
2008/0195107	A1	8/2008	Cuckler et al.	2009/0222014	A1	9/2009	Bojarski et al.
2008/0195108	A1	8/2008	Bhatnagar et al.	2009/0222015	A1	9/2009	Park et al.
2008/0195109	A1	8/2008	Hunter et al.	2009/0222016	A1	9/2009	Park et al.
2008/0195216	A1	8/2008	Philipp	2009/0222103	A1	9/2009	Fitz et al.
2008/0200926	A1	8/2008	Verard et al.	2009/0226068	A1	9/2009	Fitz et al.
2008/0208200	A1	8/2008	Crofford	2009/0228016	A1	9/2009	Alvarez et al.
2008/0208353	A1	8/2008	Kumar et al.	2009/0234360	A1	9/2009	Alexander
2008/0215059	A1	9/2008	Carignan et al.	2009/0248044	A1	10/2009	Amiot et al.
2008/0221699	A1	9/2008	Meridew et al.	2009/0254093	A1	10/2009	White et al.
2008/0230422	A1	9/2008	Pleil et al.	2009/0254367	A1	10/2009	Belcher et al.
2008/0234664	A1	9/2008	May et al.	2009/0259312	A1	10/2009	Shterling et al.
2008/0234683	A1	9/2008	May	2009/0270868	A1	10/2009	Park et al.
2008/0234685	A1	9/2008	Gjerde	2009/0274350	A1	11/2009	Pavlovskaja et al.
2008/0234833	A1	9/2008	Bandoh et al.	2009/0287217	A1	11/2009	Ammann et al.
2008/0243127	A1	10/2008	Lang et al.	2009/0306676	A1	12/2009	Lang et al.
2008/0255674	A1	10/2008	Rahaman et al.	2009/0307893	A1	12/2009	Burdulis, Jr. et al.
2008/0257363	A1	10/2008	Schoenefeld et al.	2009/0318836	A1	12/2009	Stone et al.
2008/0262500	A1	10/2008	Collazo	2009/0318921	A1	12/2009	White et al.
2008/0262624	A1	10/2008	White et al.	2010/0010493	A1	1/2010	Dower
2008/0269906	A1	10/2008	Iannotti et al.	2010/0016984	A1	1/2010	Trabish
2008/0275452	A1	11/2008	Lang et al.	2010/0016986	A1	1/2010	Trabish
2008/0281328	A1	11/2008	Lang et al.	2010/0023015	A1	1/2010	Park
2008/0281329	A1	11/2008	Fitz et al.	2010/0030231	A1	2/2010	Revie et al.
2008/0281426	A1	11/2008	Fitz et al.	2010/0036404	A1	2/2010	Yi et al.
2008/0287954	A1	11/2008	Kunz et al.	2010/0042105	A1	2/2010	Park et al.
2008/0294170	A1	11/2008	O'Brien	2010/0049195	A1	2/2010	Park et al.
2008/0294266	A1	11/2008	Steinberg	2010/0049327	A1	2/2010	Isch et al.
2008/0300600	A1	12/2008	Guelat et al.	2010/0057088	A1	3/2010	Shah
2008/0306485	A1	12/2008	Coon et al.	2010/0076439	A1	3/2010	Hatch
2008/0306558	A1	12/2008	Hakki	2010/0076505	A1	3/2010	Borja
2008/0312659	A1	12/2008	Metzger et al.	2010/0076563	A1	3/2010	Otto et al.
2008/0319448	A1	12/2008	Lavallee et al.	2010/0076571	A1	3/2010	Hatch
2009/0012526	A1	1/2009	Fletcher	2010/0082034	A1	4/2010	Remia
2009/0018546	A1	1/2009	Daley	2010/0082035	A1	4/2010	Keefer
2009/0018666	A1	1/2009	Grundeil et al.	2010/0087829	A1	4/2010	Metzger et al.
2009/0024131	A1	1/2009	Metzger et al.	2010/0094295	A1	4/2010	Schnieders et al.
2009/0043556	A1	2/2009	Axelson et al.	2010/0105011	A1	4/2010	Karkar et al.
2009/0076371	A1	3/2009	Lang et al.	2010/0121334	A1	5/2010	Couture et al.
2009/0076512	A1	3/2009	Ammann et al.	2010/0121335	A1	5/2010	Penenberg et al.
2009/0076520	A1	3/2009	Choi	2010/0131073	A1	5/2010	Meridew et al.
2009/0082770	A1	3/2009	Worner et al.	2010/0136214	A1	6/2010	Kumar
2009/0082774	A1	3/2009	Oti et al.	2010/0137869	A1	6/2010	Borja et al.
2009/0087276	A1	4/2009	Rose	2010/0137924	A1	6/2010	Tuke et al.
2009/0088674	A1	4/2009	Caillouette et al.	2010/0145343	A1	6/2010	Johnson et al.
2009/0088753	A1	4/2009	Aram et al.	2010/0145344	A1	6/2010	Jordan et al.
2009/0088754	A1	4/2009	Aker et al.	2010/0145466	A1	6/2010	Slone
2009/0088755	A1	4/2009	Aker et al.	2010/0152782	A1	6/2010	Stone et al.
2009/0088758	A1	4/2009	Bennett	2010/0160917	A1	6/2010	Fitz et al.

GB	2197790	A	6/1988
GB	2442441	A	4/2008
GB	2447702	A	9/2008
GB	2483980	A	3/2012
GB	2486390	A	6/2012
GB	2490220	A	10/2012
GB	2491526	A	12/2012
JP	59157715	A	9/1984
JP	60231208	A	11/1985
JP	2011505080	A	2/2011
JP	2011527885	A	11/2011
KR	20050072500	A	7/2005
KR	20050084024	A	8/2005
RU	2083179	C1	7/1997
RU	2113182	C1	6/1998
RU	2125835	C1	2/1999
RU	2138223	C1	9/1999
RU	2175534	C2	11/2001
RU	2187975	C1	8/2002
TW	231755		5/2005
WO	WO-8807840	A1	10/1988
WO	WO-9107139	A1	5/1991
WO	WO-9325157	A1	12/1993
WO	WO-9528688	A1	10/1995
WO	WO-9952473	A1	10/1999
WO	WO-9959106	A1	11/1999
WO	WO-0170142	A1	9/2001
WO	WO-0184479	A1	11/2001
WO	WO-0217821	A2	3/2002
WO	WO-0226145		4/2002
WO	WO-0236024	A1	5/2002
WO	WO-02096268	A2	12/2002
WO	WO-03051210	A2	6/2003
WO	WO-03051211	A1	6/2003
WO	WO-2004032806	A1	4/2004
WO	WO-2004049981	A2	6/2004
WO	WO-2004051301	A2	6/2004
WO	WO-200407806	A2	9/2004
WO	WO-200505124	A1	6/2005
WO	WO-2005051239	A1	6/2005
WO	WO-2005077039	A2	8/2005
WO	WO-2006058057	A2	6/2006
WO	WO-2006060795	A1	6/2006
WO	WO-2006092600	A1	9/2006
WO	WO-2006127486	A2	11/2006
WO	WO-2006134345	A1	12/2006
WO	WO-2006136955	A1	12/2006
WO	WO-2007041375	A2	4/2007
WO	WO-2007053572	A2	5/2007
WO	WO-2007062079	A2	5/2007
WO	WO-2007092841	A2	8/2007
WO	WO-2007137327	A1	12/2007
WO	WO-2007145937	A2	12/2007
WO	WO-2008014618	A1	2/2008
WO	WO-2008021494	A2	2/2008
WO	WO-2008040961	A1	4/2008
WO	WO-2008044055	A1	4/2008
WO	WO-2008091358	A1	7/2008
WO	WO-2008101090	A2	8/2008
WO	WO-2008109751	A1	9/2008
WO	WO-2008112996	A1	9/2008
WO	WO-200814074	A1	11/2008
WO	WO-2009001083	A1	12/2008
WO	WO-2009025783	A1	2/2009
WO	WO-2009073781	A2	6/2009
WO	WO-2009129063	A1	10/2009
WO	WO-2009129067	A1	10/2009
WO	WO-2010033431	A1	3/2010
WO	WO-2010093902	A1	8/2010
WO	WO-2010096553	A1	8/2010
WO	WO-2010096557	A2	8/2010
WO	WO-2010124164	A1	10/2010
WO	WO-2010144705	A1	12/2010
WO	WO-2010148103	A1	12/2010
WO	WO-2011018458	A1	2/2011
WO	WO-2011041398	A1	4/2011
WO	WO-2011060536	A1	5/2011
WO	WO-2011019797	A3	7/2011
WO	WO-2011106711	A1	9/2011

WO	WO-2011109260	A1	9/2011
WO	WO-2011110374	A1	9/2011
WO	WO-2012006444	A2	1/2012
WO	WO-2012033821	A1	3/2012
WO	WO-2012058344	A1	5/2012
WO	WO-2012061042	A1	5/2012
WO	WO-2012058353	A4	6/2012
WO	WO-2012058355	A4	7/2012
WO	WO-2012058349	A4	8/2012
WO	WO-2012116206	A1	8/2012
WO	WO-2012158917	A1	11/2012
WO	WO-2012173929	A1	12/2012
WO	WO-2012174008	A1	12/2012

OTHER PUBLICATIONS

“Ascent Total Knee System,” brochure. Biomet, Inc. (1999) 16 sheets.

“Customized Patient Instruments, Patient specific instruments for patient specific needs,” brochure. (2008) DePuy Orthopaedics, Inc. 14 sheets.

“Customized Patient Instruments, Primary Cruciate Retaining Surgical Technique for use with the Sigma® Knee System Utilizing Specialist® 2 Instrumentation,” brochure. (2008) DePuy Orthopaedics, Inc. pp. 1-23.

“Discovery® Elbow System Surgical Technique,” brochure. Biomet Orthopedics, Inc. (2008) pp. 1-25.

“Discovery® Elbow System,” brochure. Biomet Orthopedics, Inc. (2007) 3 sheets.

“Hipsextant Instructions of Use.” (2011) Surgical Planning Associates, Inc. 19 pages.

“Knee tensor combined with laser femoral head locator,” Research Disclosure. Jul. 2006. No. 507; p. 903.

“Method for constructing an allograft sleeve.” Research Disclosure (Dec. 2003) No. 476, p. 1294.

“OSS™ Orthopaedic Salvage System, Femoral/Tibial Augmentation,” brochure. Biomet Orthopedics, Inc., (2003) pp. 1-8 (12 sheets).

“Patient Matched PMI Implants, C.A.M.R.A. 3-D Imaging,” brochure, Biomet, Inc. (1990) 6 pages.

“Regenerex® Tibial Cone Augment, Surgical Technique Addendum to the Vanguard® SSK Revision System,” brochure. Biomet® Orthopedics. (2009) pp. 1-8 (12 sheets).

“Signature™ Personalized Patient Care, Surgical Technique Addendum to the Vanguard Knee System” brochure. Biomet® Orthopedics, Inc. (2009) pp. 1-8.

“TruMatch™ Personalized knee replacement solutions,” tri-fold brochure. (2009) SIGMA® DePuy Orthopaedics, Inc. 2 pages.

“Vanguard® PFR Partial Knee Patellofemoral Replacement System,” Surgical Technique brochure. Biomet Orthopaedics, (2010) pp. 1-25.

“Zimmer® UniSpacer® Knee System,” brochure. (2005) Zimmer, Inc. 4 sheets.

Birnbaum, Klaus, M.D., “Computer-Assisted Orthopedic Surgery With Individual Templates and Comparison to Conventional Method,” SPINE vol. 26, No. 4, pp. 365-370 (2001) Lippincott Williams & Wilkins, Inc.

Botha, Charl P., Technical Report: DeVIDE—The Delft Visualisation and Image processing Development Environment, pp. 1-49 (May 31, 2006).

Cohen, Zohara A., et al. “Knee cartilage topography, thickness, and contact areas from MRI: in-vitro calibration and in-vivo measurements.” Journal of the Osteoarthritis Research Society International. Osteoarthritis and Cartilage, (1999) vol. 7; No. 1 pp. 95-109.

Eckhoff, Donald G., et al., “Three-Dimensional Mechanics, Kinematics, and Morphology of the Knee Viewed in Virtual Reality,” The Journal of Bone & Joint Surgery, vol. 81 (Dec. 4, 2005) pp. 71-80.

Fortin, Thomas, D.D.S., Ph.D., et al., “Precise Dental Implant Placement in Bone Using Surgical Guides in Conjunction with Medical Imaging Techniques,” Journal of Oral Implantology, Clinical, vol. 26, No. 4 (2000) pp. 300-303.

Haaker, R.G., et al., “Minimal-invasive navigiert implantierte unikondyläre Knieendoprothese,” Orthopäde 2006 35:1073-1079 (2006) Springer Medizin Verlag.

- Hafez, M.A., et al., "Computer-assisted Total Knee Arthroplasty Using Patient-specific Templating," *Clinical Orthopaedics and Related Research*, No. 444 (pp. 184-192) 2006 Lippincott Williams & Wilkins.
- Hazen, Eric J., M.D., "Computer-Assisted Orthopaedic Surgery, A New Paradigm," *Techniques in Orthopaedics®* vol. 18, No. 2, (2003) pp. 221-229.
- Hutmacher, Dietmar, W., "Scaffolds in tissue engineering bone and cartilage," *Biomaterials*, 2000 Elsevier Science Ltd. (pp. 2529-2543). International Preliminary Report on Patentability and Written Opinion for PCT/US2009/039578 mailed Oct. 28, 2010 claiming benefit of U.S. Appl. No. 12/103,834, filed Apr. 16, 2008.
- International Preliminary Report on Patentability and Written Opinion mailed Oct. 28, 2010 for PCT/US2009/039507 claiming benefit of U.S. Appl. No. 12/103,824, filed Apr. 16, 2008.
- International Preliminary Report on Patentability for PCT/US2007/013223 mailed Dec. 24, 2008 claiming benefit of U.S. Appl. No. 11/756,057, filed May 31, 2007.
- International Preliminary Report on Patentability mailed Mar. 31, 2011 for PCT/US2009/056670 claiming benefit of U.S. Appl. No. 12/211,407, filed Sep. 16, 2008.
- International Search Report and Written Opinion for PCT/US2007/013223 mailed Nov. 26, 2007, claiming benefit of U.S. Appl. No. 11/756,057, filed May 31, 2007.
- International Search Report and Written Opinion for PCT/US2009/039507 mailed Jul. 14, 2009, claiming benefit of U.S. Appl. No. 12/103,824.
- International Search Report and Written Opinion for PCT/US2009/056670 mailed Mar. 2, 2010 claiming benefit of U.S. Appl. No. 12/211,407, filed Sep. 16, 2008.
- International Search Report and Written Opinion mailed Apr. 22, 2010 for PCT/US2010/024579 claiming benefit of U.S. Appl. No. 12/389,930, filed Feb. 20, 2009.
- International Search Report and Written Opinion mailed Aug. 19, 2010 for PCT/US2010/024584 claiming benefit of U.S. Appl. No. 12/389,901, filed Feb. 20, 2009.
- International Search Report and Written Opinion mailed Dec. 7, 2010 for PCT/US2010/050701 claiming benefit of U.S. Appl. No. 12/571,969, filed Oct. 1, 2009.
- International Search Report and Written Opinion mailed Jul. 31, 2009 for PCT/US2009/039578 claiming benefit of U.S. Appl. No. 12/103,834, filed Apr. 16, 2008.
- International Search Report and Written Opinion mailed Jun. 10, 2010 for PCT/US2010/038177 claiming benefit of U.S. Appl. No. 12/483,807, filed Jun. 12, 2009.
- International Search Report and Written Opinion mailed Jun. 4, 2010 for PCT/US2010/024073 filed Feb. 12, 2010, claiming benefit of U.S. Appl. No. 12/371,096, filed Feb. 13, 2009.
- International Search Report and Written Opinion mailed May 9, 2011 for PCT/US2011/026412 claiming benefit of U.S. Appl. No. 12/872,663, filed Aug. 31, 2010.
- International Search Report and Written Opinion mailed Oct. 5, 2010 for PCT/US2010/038845 claiming benefit of U.S. Appl. No. 12/486,992, filed Jun. 18, 2009.
- Invitation to Pay Additional Fees mailed May 3, 2011 for PCT/US2011/026333 claiming benefit of U.S. Appl. No. 12/714,023, filed Feb. 26, 2010.
- Invitation to Pay Additional Fees with Partial International Search mailed Nov. 26, 2009 for PCT/US2009/056670.
- Kaus, Michael R., Ph.D., "Automated Segmentation of MR Images of Brain Tumors," *Radiology*, vol. 218, No. 2, (2001) pp. 586-591.
- Kelly, Todd C., M.D., "Role of Navigation in Total Hip Arthroplasty," *The Journal of Bone & Joint Surgery* (2009) pp. 153-158. vol. 91-A, Supplement 1.
- Klein, M., "Robot assisted insertion of craniofacial implants—clinical experience," *CARS 2001*, pp. 133-138 (2001) Elsevier Science B.V.
- Lombardi, Adolph, et al., "Patient-Specific Approach in Total Knee Arthroplasty," *Knee Orthopedics, ORTHOSuperSite* (Sep. 1, 2008), 5 pages, <http://www.orthosupersite.com/view.aspx?rid=31419>, printed May 20, 2010.
- Lynch, John A., et al., "Cartilage segmentation of 3D MRI scans of the osteoarthritic knee combining user knowledge and active contours," *Medical Imaging 2000: Image Processing SPIE* vol. 3979 (2000) pp. 925-935.
- Murphy, S.B., et al. "The Hip Sextant: Navigation of Acetabular Component Orientation Using a Mechanical Instrument," brochure. (2009) 1 page.
- Nicholls, Paul, M.D., "Trauma Grand Rounds PMI (Patient-Matched Implants)" brochure, Biomet Orthopedics, Inc., (Feb. 29, 2000) 1 page.
- Overhoff, H.M., et al., "Total Knee Arthroplasty: Coordinate System Definition and Planning based on 3-D Ultrasound Image Volumes," *CARS 2001*, pp. 283-288, (2001) Elsevier Science B.V.
- Portheine, F., "CT-basierte Planung und DISOS-Schablonennavigation in der Kniegelenkendoprothetik," in *Navigation und Robotik in der Gelenk—und Wirbelsäulen Chirurgie*, Kapitel 32, Springer Verlag (2003) pp. 262-269.
- Portheine, F., et al., *Entwicklung eines klinischen Demonstrators für die computerunterstützte Orthopädische Chirurgie mit CT-Bildbasierten Individualschablonen, Bildverarbeitung für die Medizin* (1998) 5 pages.
- Portheine, K., "Development of a clinical demonstrator for computer assisted orthopedic surgery with CT-image based individual templates," *Computer Assisted Radiology and Surgery*, pp. 944-949, (1997) Elsevier Science B.V.
- Radermacher, "Computer Assisted Orthopaedic Surgery with Image Based Individual Templates," *Clinical Orthopaedics and Related Research* No. 354, pp. 28-38 (1998) Lippincott Williams & Wilkins.
- Radermacher, K., et al., "Computer Integrated Orthopaedic Surgery: Connection of Planning and Execution in Surgical Intervention," *Computer-integrated surgery: technology and clinical applications*, (1996) pp. 451-463.
- Radermacher, K., et al., "CT Image-Based Planning and Execution of Interventions in Orthopedic Surgery Using Individual Templates, Experimental Results and Aspects of Clinical Applications," *Computer Assisted Orthopedic Surgery (CAOS)*, pp. 42-52, (1995) Hogrefe & Huber Publishers.
- Radermacher, K., et al., "Image Guided Orthopedic Surgery Using Individual Templates," *Springer Berlin/Heidelberg, CVRMed-MRCAS'97*, vol. 1205/1997 pp. 606-615).
- Radermacher, K., et al., "Technique for Better Execution of CT Scan Planned Orthopedic Surgery on Bone Structures," *Supplied by the British Library—"The world's knowledge" 2nd Congress of ISCAS Conference in Berlin Germany* (Jun. 1995) pp. 933-938.
- Radermacher, Klaus, et al. "Computer Assisted Orthopaedic Individual Templates." *Clinical Orthopaedics and Related Research*. (Sep. 1998) No. 354; pp. 28-38.
- Schuller-Götzburg, P., et al., *3D-Implantatplanung und Stereolithographie-Implantatbohrschablonen*, *Stomatologie* 101.3, pp. 55-59 (2004).
- Sharp, S. Michael, Ph.D., *Patient-Specific, Resurfacing Bi-Compartmental Arthroplasty*, *Futuretech, Orthopaedic Product News* (Mar./Apr. 2008) pp. 12-15.
- Sisto, Domenick, J., et al., "Custom Patellofemoral Arthroplasty of the Knee Surgical Technique," *Journal of Bone and Joint Surgery*, vol. 89-A, pp. 214-225 (2007).
- Slammin, John et al, "Do You Have This Implant in My Size?," *MDT Medical Design Technology*, 3 pages, <http://www.mdtmag.com/scripts/ShowPR.asp?PUBCODE=046&ACCT=0007796&IS-SUE...> accessed Jul. 31, 2008.
- Steinwachs, Matthias Reinhard, "Cartilage Repair—Autologous Chondrocyte Transplantation and Autologous Matrix-induced Chondrogenesis," *European Musculoskeletal Review* (2006) pp. 65-68.
- Biomet "Oxford® Partial Knee" brochure, 8 pages (Feb. 2011).
- Biomet "The Oxford® Partial Knee Surgical Technique," brochure, pp. 1-38, (Feb. 2010).
- Biomet, "Oxford® Partial Knee Microplasty® Instrumentation Surgical Technique", brochure, pp. 1-54 (May 2011).
- International Preliminary Report on Patentability and Written Opinion mailed Sep. 7, 2012 for PCT/US2011/026333 claiming benefit of U.S. Appl. No. 12/714,023, filed Feb. 26, 2010.

- International Preliminary Report on Patentability for PCT/US2010/050701 mailed Apr. 12, 2012 claiming benefit of U.S. Appl. No. 12/571,969, filed Oct. 1, 2009.
- International Search Report and Written Opinion mailed Mar. 5, 2012 for PCT/US2011/057300 claiming benefit of U.S. Appl. No. 12/938,905, filed Nov. 3, 2010.
- International Search Report and Written Opinion mailed May 8, 2012 for PCT/US2012/026356 claiming benefit of U.S. Appl. No. 13/041,883, filed Mar. 7, 2011.
- Thoma, W., et al., "Endoprothetischen Versorgung des Kniegelenks auf der Basis eines 3D-computertomographischen Subtraktionverfahrens," Zuma Thema: Computergestützte orthopädische Chirurgie, *Der Orthopäde* 29:641-644 Springer-Verlag (Jul. 2000) Translation provided: Thoma, W. "Endoprosthetic care of the knee joint based on a 3D computer chromatography subtraction process," Topic: Computer-aided orthopedic surgery. *Orthopedist* 2000 29:641-644 Springer Verlag (Jul. 2000).
- Great Britain Search Report mailed Dec. 21, 2011 for GB1116054.6, claiming benefit of U.S. Appl. No. 12/888,005, filed Sep. 22, 2010.
- International Preliminary Report and Written Opinion mailed Jan. 5, 2012 for PCT/US2010/038845 claiming benefit of U.S. Appl. No. 12/486,992, filed Jun. 18, 2009.
- International Preliminary Report on Patentability and Written Opinion mailed Dec. 22, 2011 for PCT/US2010/038177 claiming benefit of U.S. Appl. No. 12/483,807, filed Jun. 12, 2009.
- International Search Report mailed Nov. 30, 2010 for PCT/EP2010/061630 filed Aug. 10, 2010 claiming benefit of DE102009028503.2 filed Aug. 13, 2009.
- Supplementary European Search Report mailed Nov. 15, 2011 for EP07809326, which claims benefit of PCT/US2007/013223, filed Jun. 5, 2007; which claims priority to U.S. Appl. No. 11/756,057, filed May 31, 2007.
- "Comprehensive® Reverse Shoulder System Surgical Technique," Biomet Orthopedics brochure (2009-2012), 48 pages.
- "Comprehensive® Reverse Shoulder System Technical Design Features," Biomet Orthopedics brochure (2009), 3 pages.
- "Comprehensive® Reverse Shoulder System," Biomet Orthopedics brochure (2009), 8 pages.
- "Comprehensive® Shoulder System Surgical Technique," Biomet Orthopedics brochure (2007), pp. 1-53.
- "Comprehensive® Total Shoulder System," Biomet Orthopedics brochure (2011), 4 pages.
- Friedman, R.J. et al., "The Use of Computerized Tomography in the Measurement of Glenoid Version", *Journal of Bone & Joint Surgery Am. (JBJS)* 1992;74:1032-1037 (Aug. 1992).
- International Search Report and Written Opinion mailed Dec. 18, 2012 for PCT/US2012/059189, which claims benefit of U.S. Appl. No. 13/597,478, filed Aug. 29, 2011.
- International Search Report and Written Opinion mailed Feb. 6, 2013 for PCT/US2012/060842, which claims benefit of U.S. Appl. No. 13/653,868, filed Oct. 17, 2012.
- International Search Report and Written Opinion mailed Feb. 6, 2013 for PCT/US2012/060854, which claims benefit of U.S. Appl. No. 13/653,893, filed Oct. 17, 2012.
- International Search Report and Written Opinion mailed Nov. 15, 2012, for PCT/US2012/052853, which claims benefit of U.S. Appl. No. 13/221,968, filed Aug. 31, 2011.
- International Search Report mailed Oct. 23, 2012, for PCT/US2012/041893, which claims benefit of U.S. Appl. No. 61/496,177, filed Jun. 13, 2011.
- Invitation to Pay Additional Fees mailed Feb. 6, 2013 for PCT/US2012/060848, which claims benefit of U.S. Appl. No. 13/653,878, filed Oct. 17, 2012.
- Invitation to Pay Additional Fees mailed Feb. 7, 2013 for PCT/US2012/060853, which claims benefit of U.S. Appl. No. 13/653,893, filed Oct. 17, 2012.
- "Max-Ti™ Modular Protrusio Cage," Surgical Technique brochure. Biomet Orthopedics, Inc. (2003) 10 sheets.
- "Max-Ti™ Modular Protrusio Cage," Surgical Technique brochure. Biomet Orthopedics, Inc. (2006) 12 sheets.
- "Par 5™ Protrusio Acetabular Reconstruction System," brochure. (2006) Biomet Orthopedics, Inc. 12 sheets.
- International Preliminary Report on Patentability mailed Aug. 25, 2011 for PCT/US2010/024073 filed Feb. 12, 2010, claiming benefit of U.S. Appl. No. 12/371,096, filed Feb. 13, 2009.
- International Preliminary Report on Patentability mailed Sep. 1, 2011 for PCT/US2010/024579 claiming benefit of U.S. Appl. No. 12/389,930, filed Feb. 20, 2009.
- International Preliminary Report on Patentability mailed Sep. 1, 2011 for PCT/US2010/024584 claiming benefit of U.S. Appl. No. 12/389,901, filed Feb. 20, 2009.
- International Search Report and Written Opinion mailed Aug. 9, 2011 for PCT/US2011/026333 claiming benefit of U.S. Appl. No. 12/714,023, filed Feb. 26, 2010.
- International Search Report and Written Opinion for PCT/US2013/026875 mailed Jun. 7, 2013, claiming benefit of U.S. Appl. No. 13/400,652, filed Feb. 21, 2012.
- International Preliminary Report on Patentability mailed Sep. 6, 2013 for PCT/US2012/026356 claiming benefit of U.S. Appl. No. 13/041,883, filed Mar. 7, 2011.
- International Search Report and Written Opinion mailed Oct. 14, 2013 for PCT/US2013/057097 claiming benefit of U.S. Appl. No. 13/597,478, filed Aug. 29, 2012.

* cited by examiner

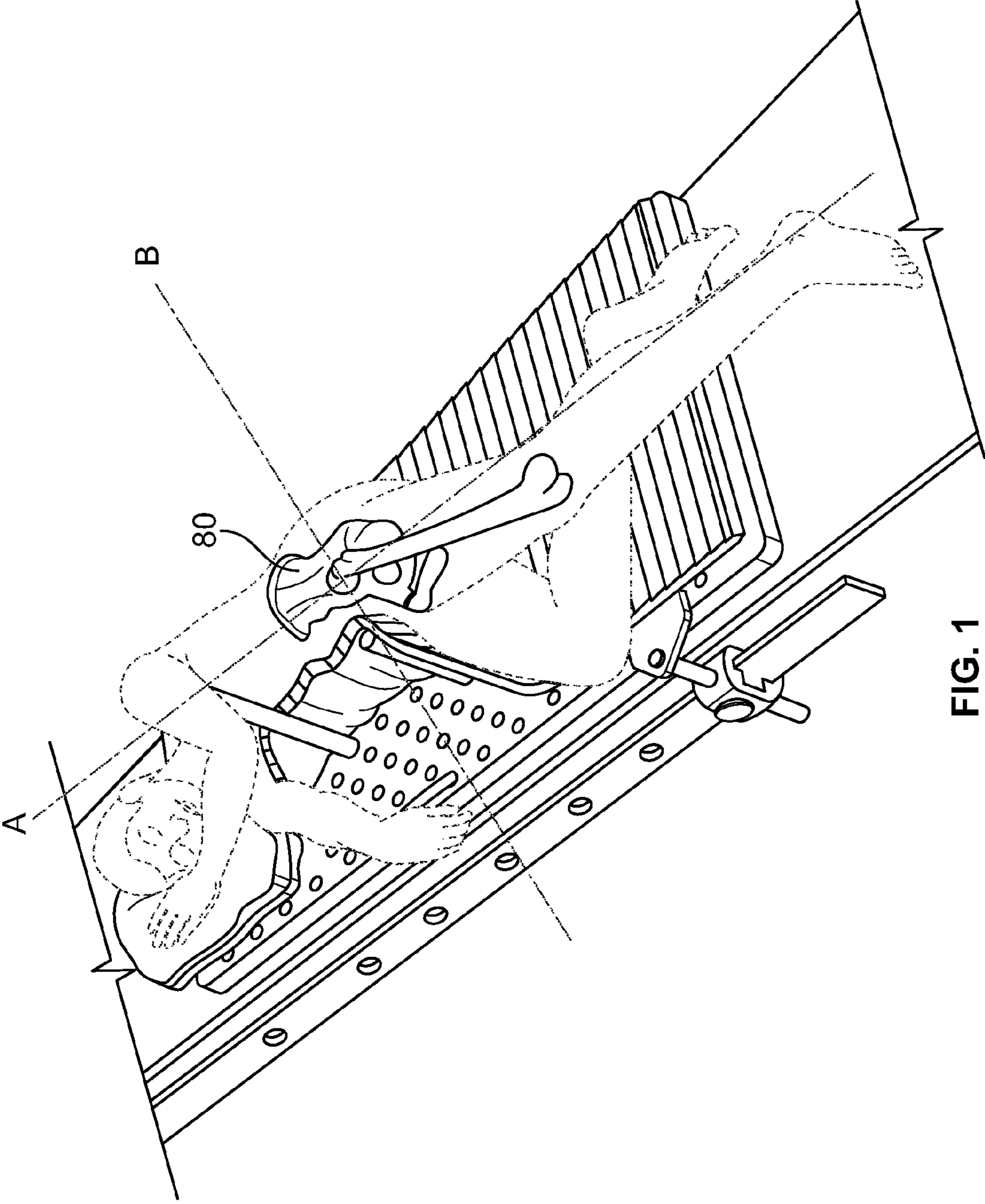


FIG. 1

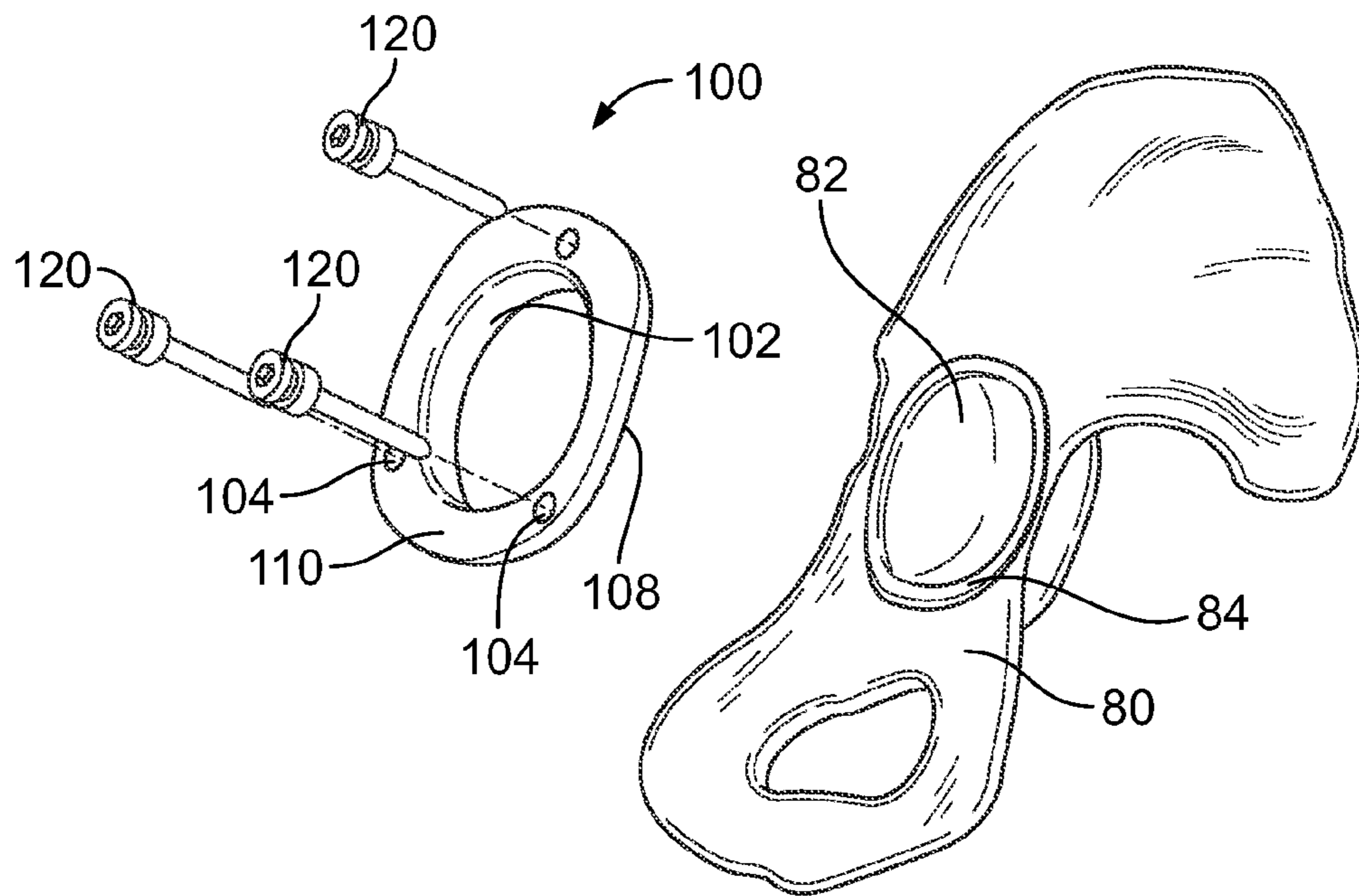


FIG. 1A

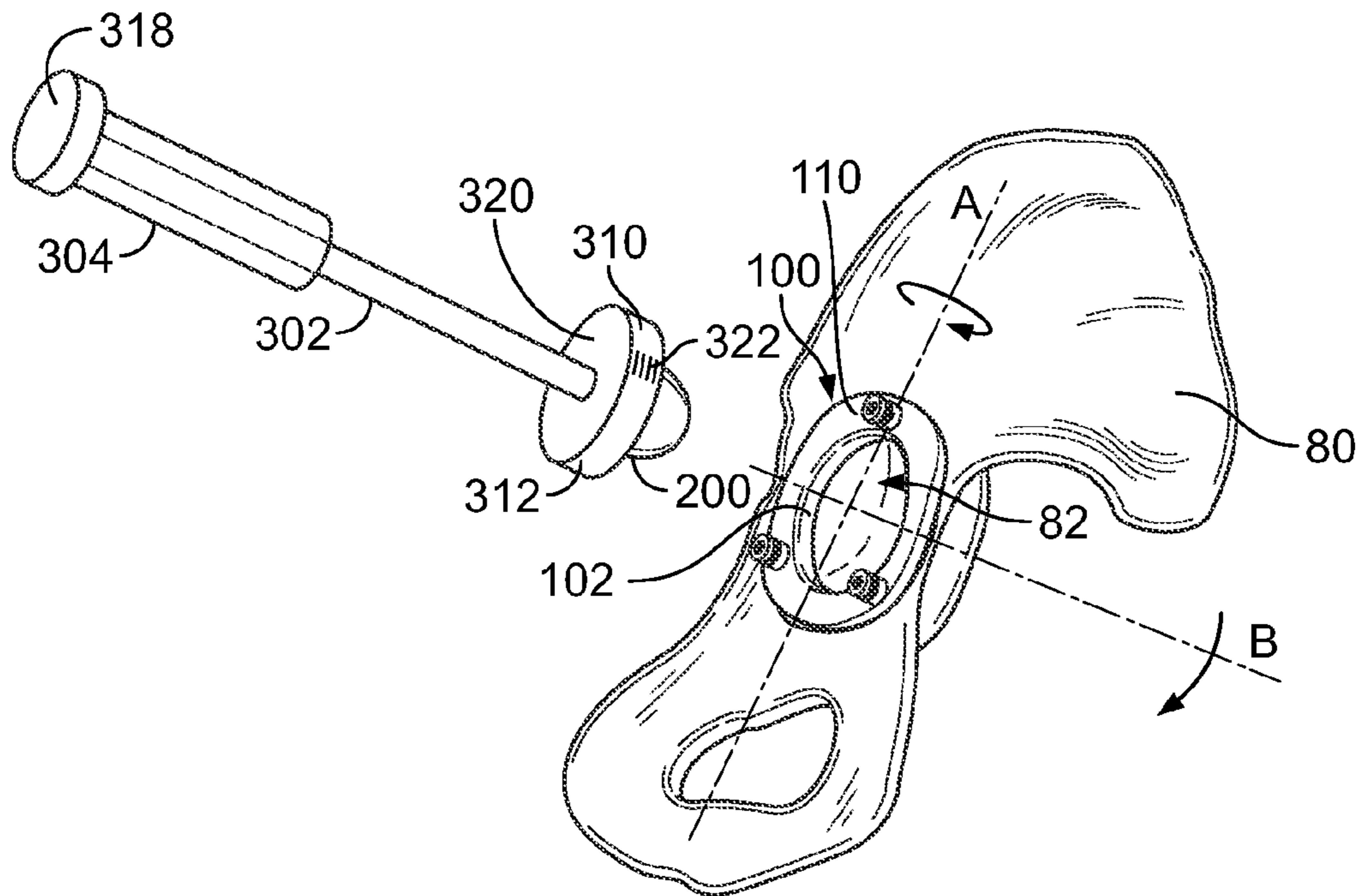
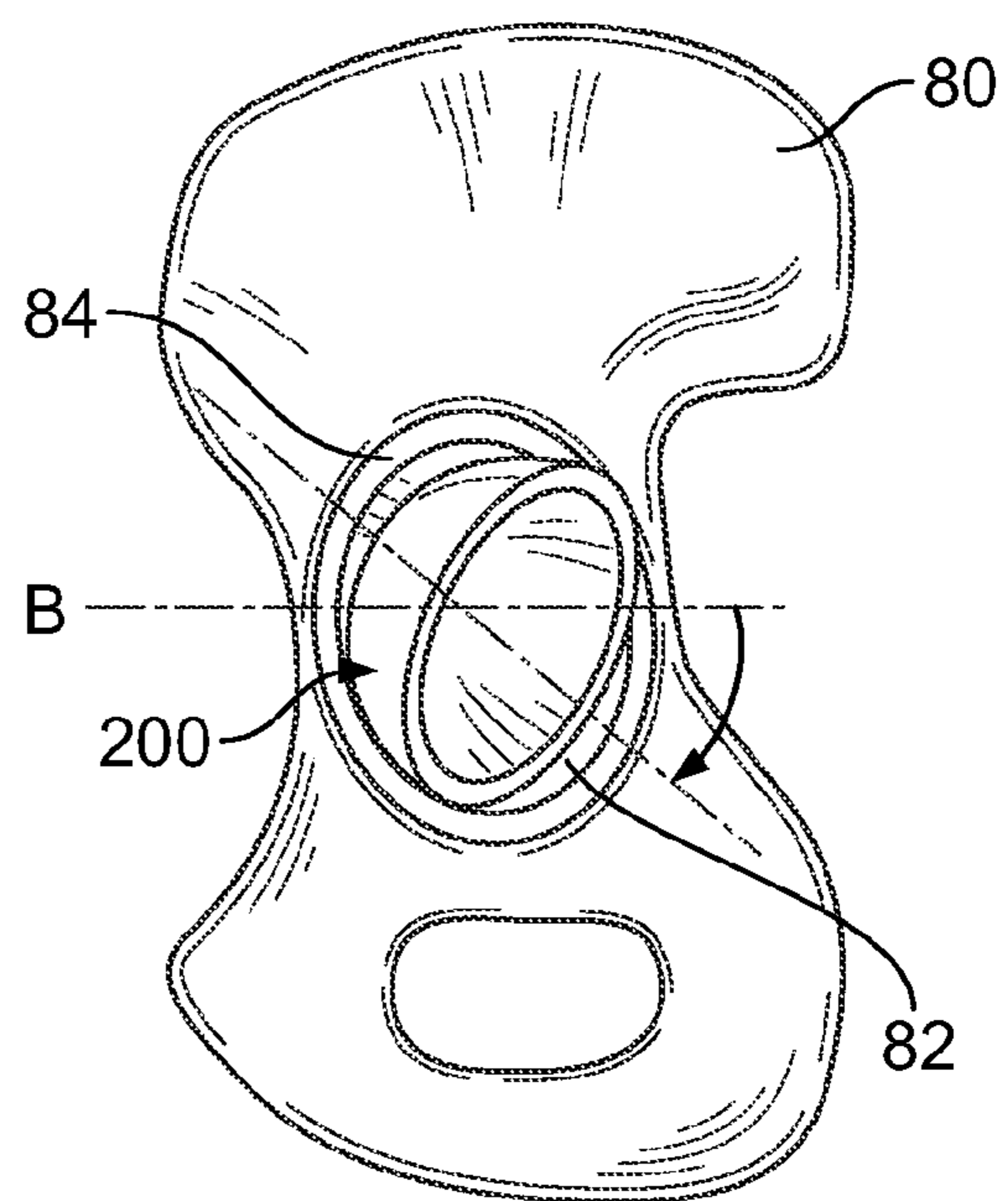
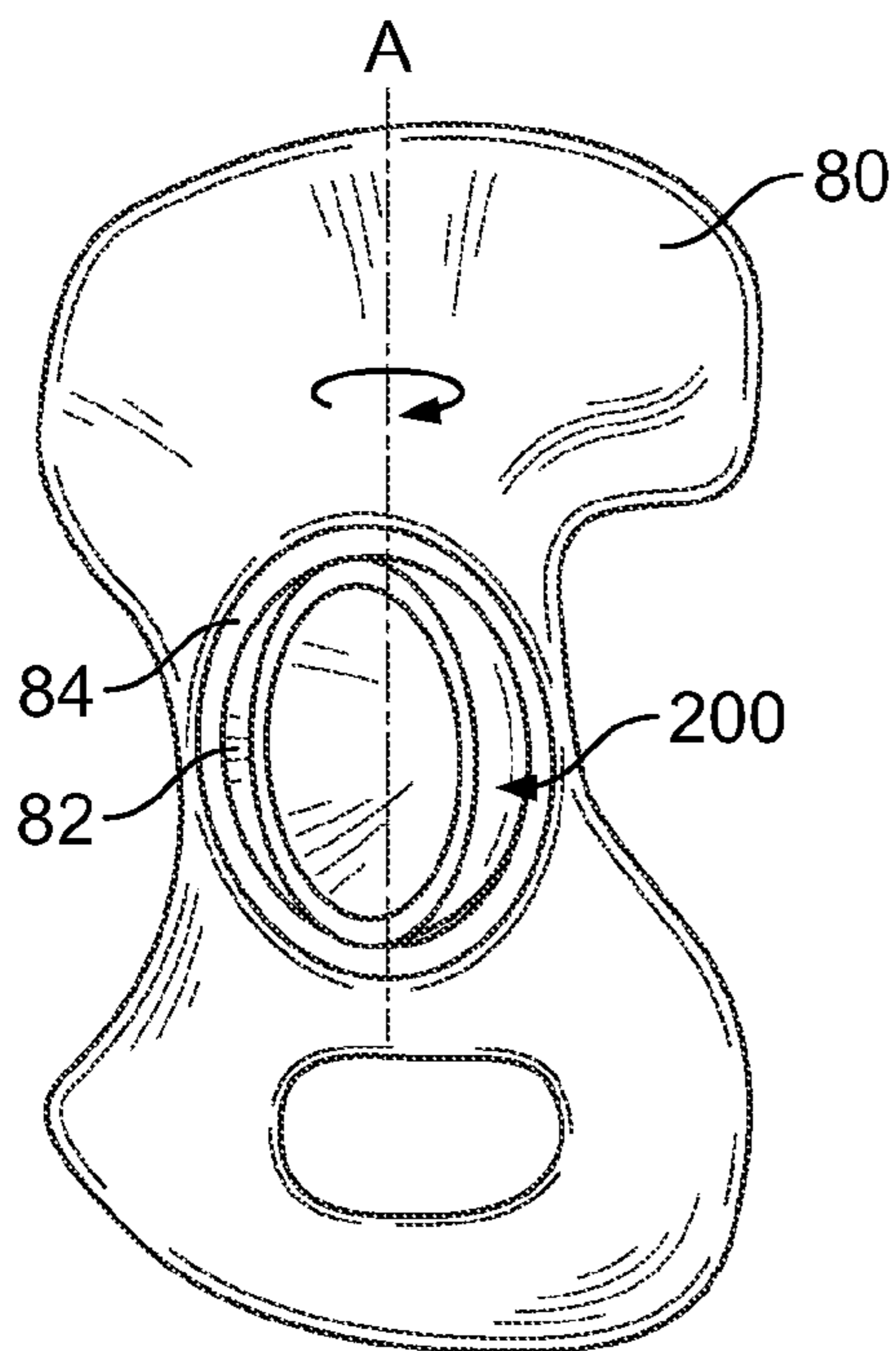
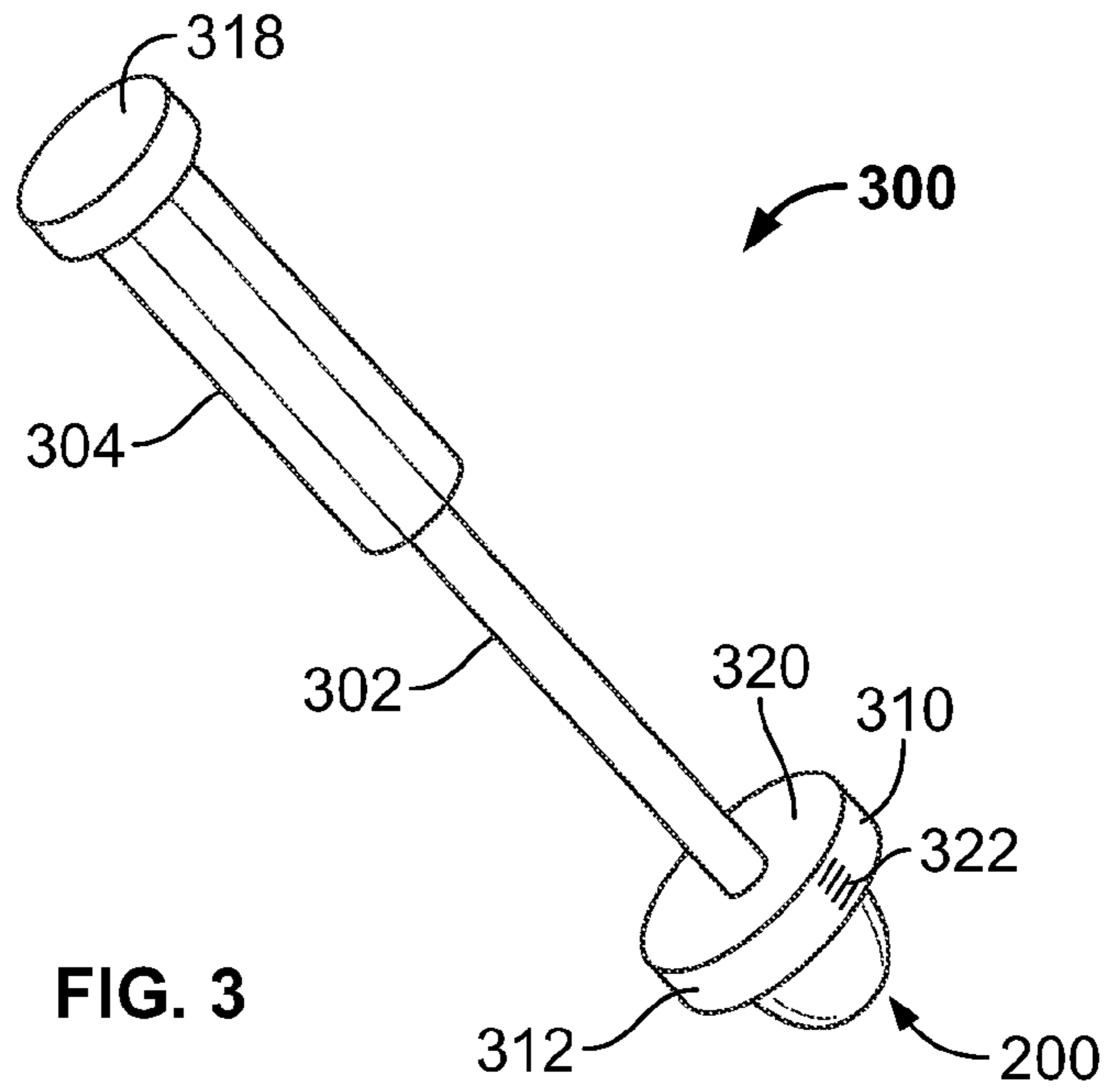


FIG. 2



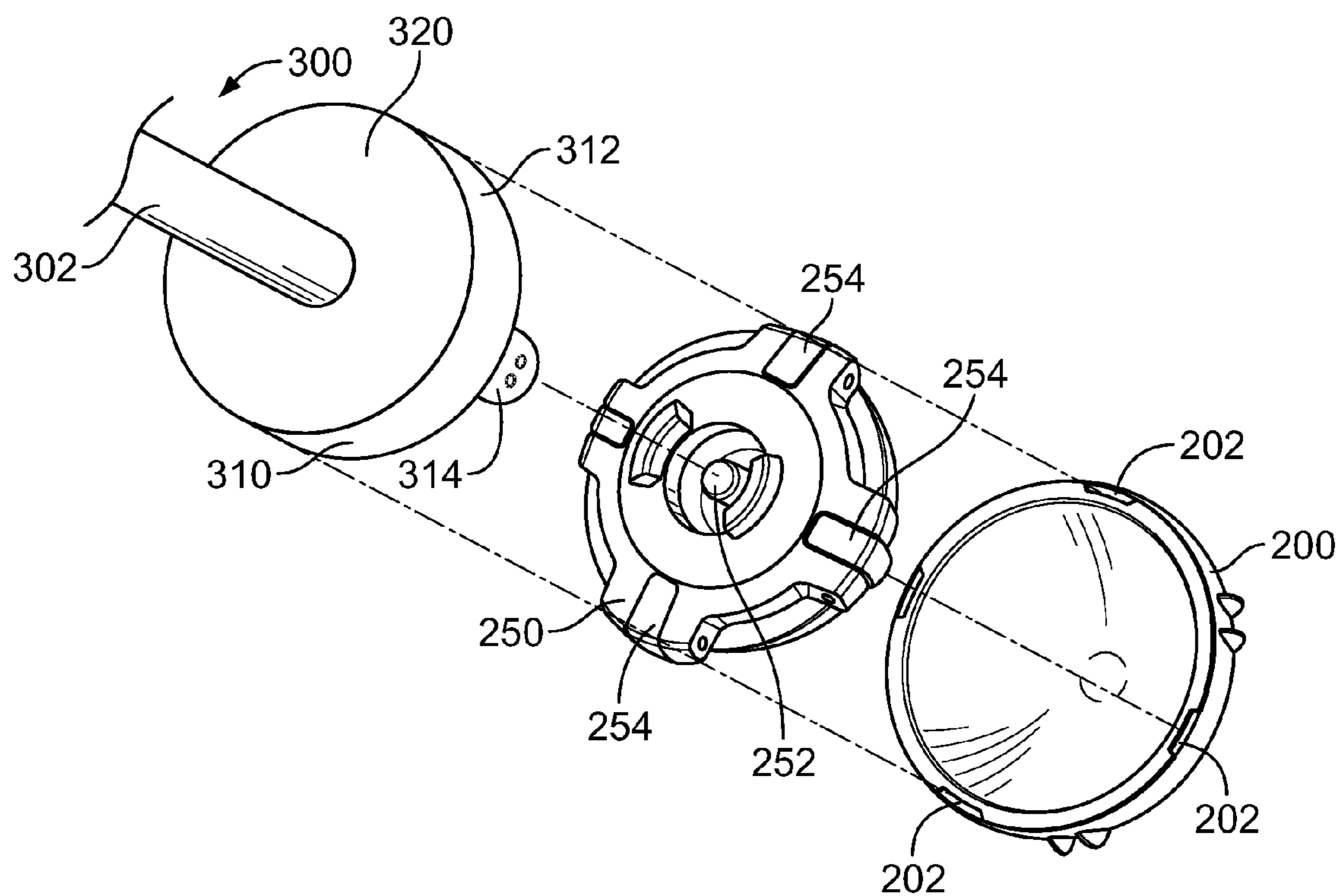


FIG. 4

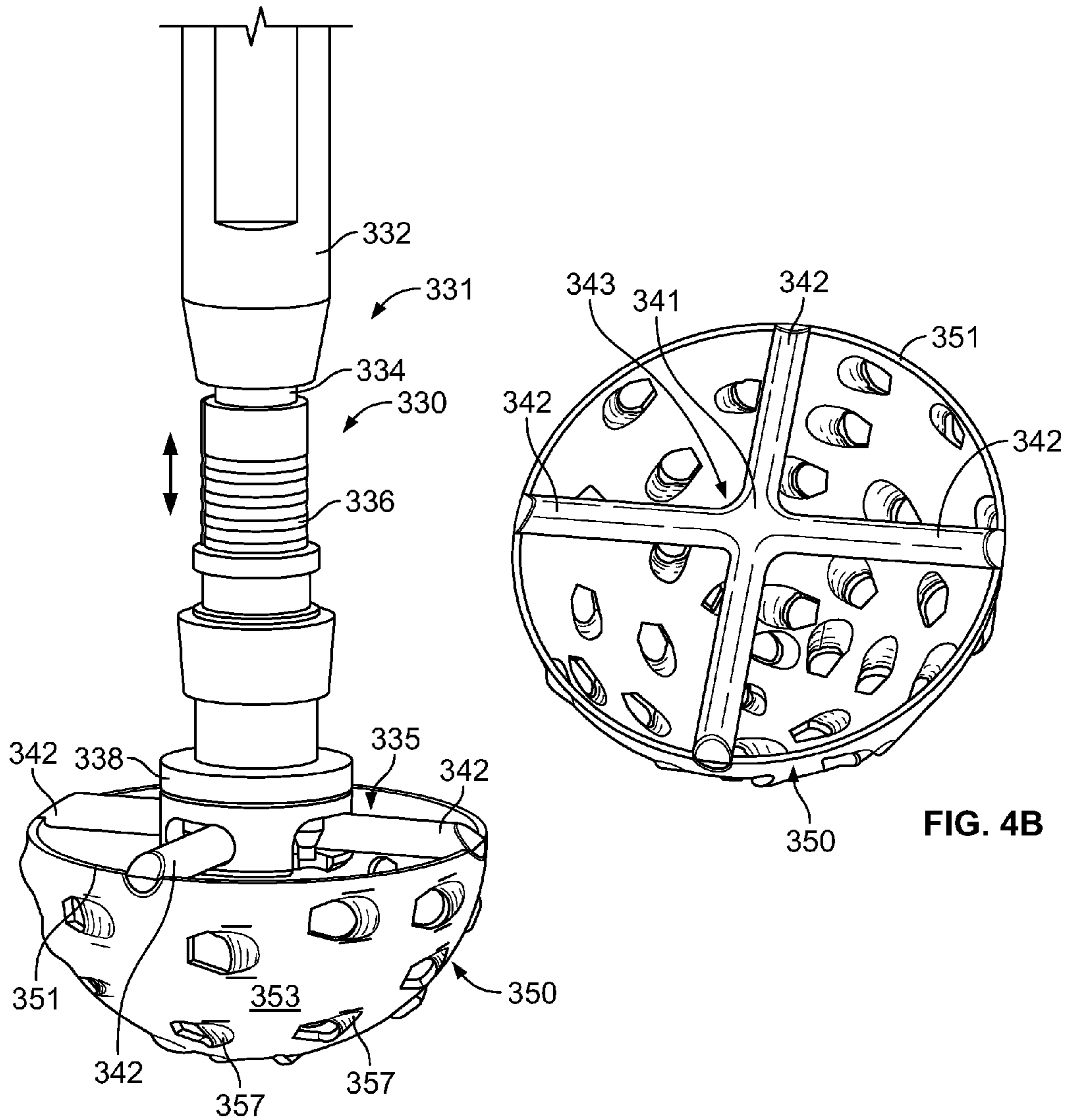


FIG. 4A

FIG. 4B

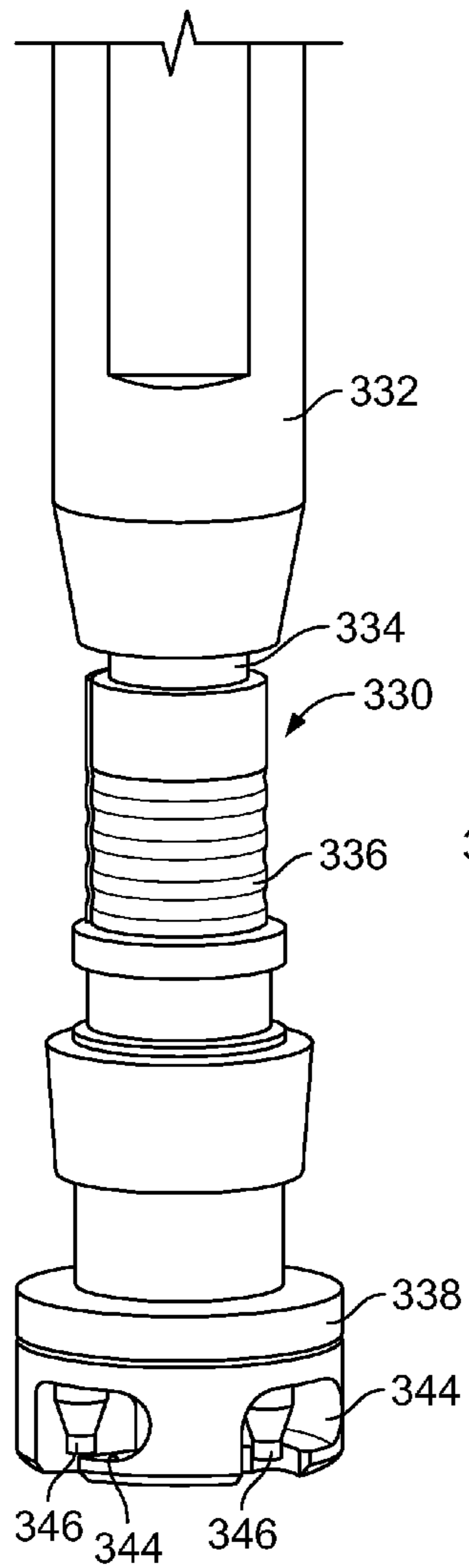


FIG. 4C

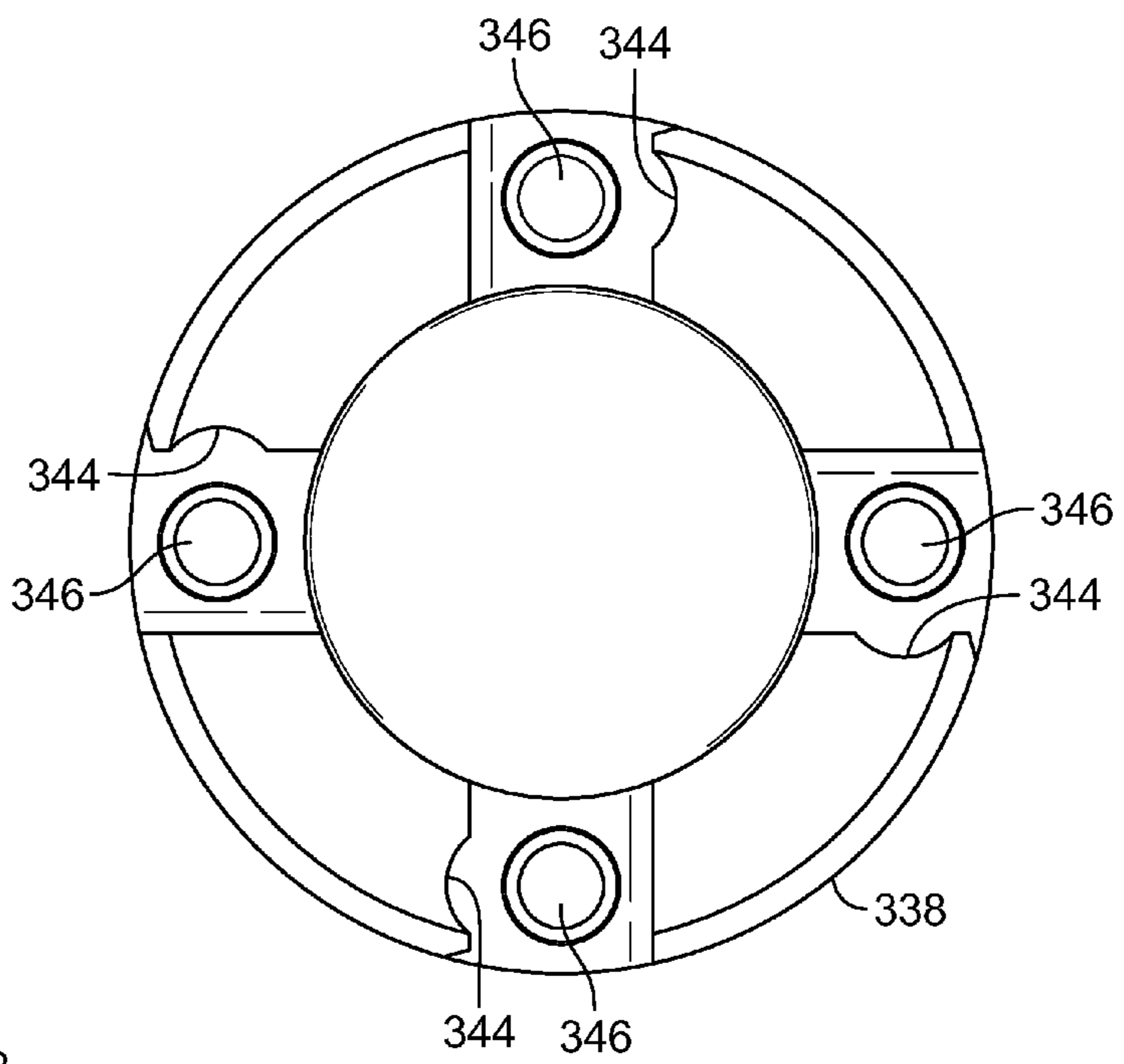


FIG. 4D

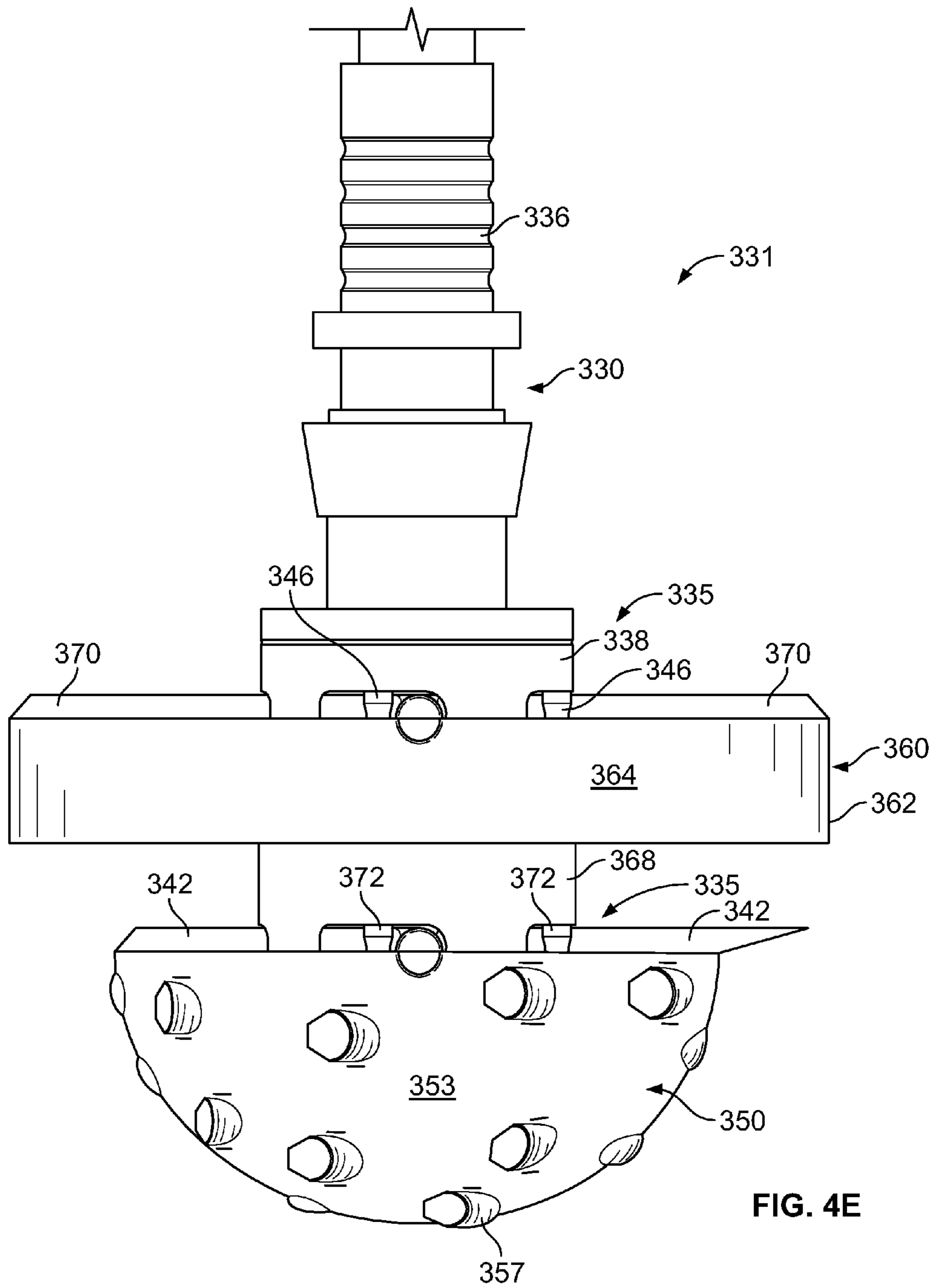


FIG. 4E

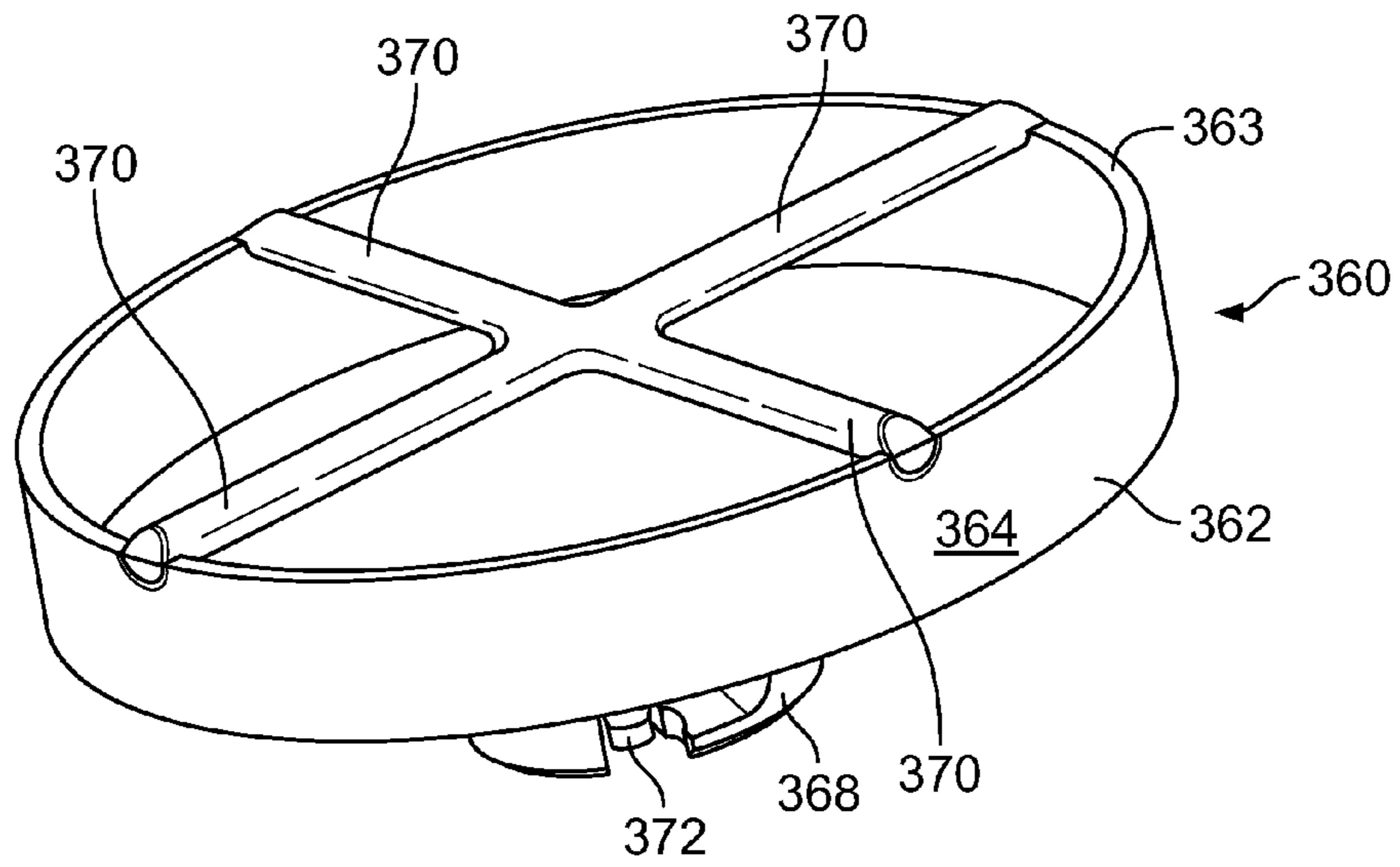


FIG. 4F

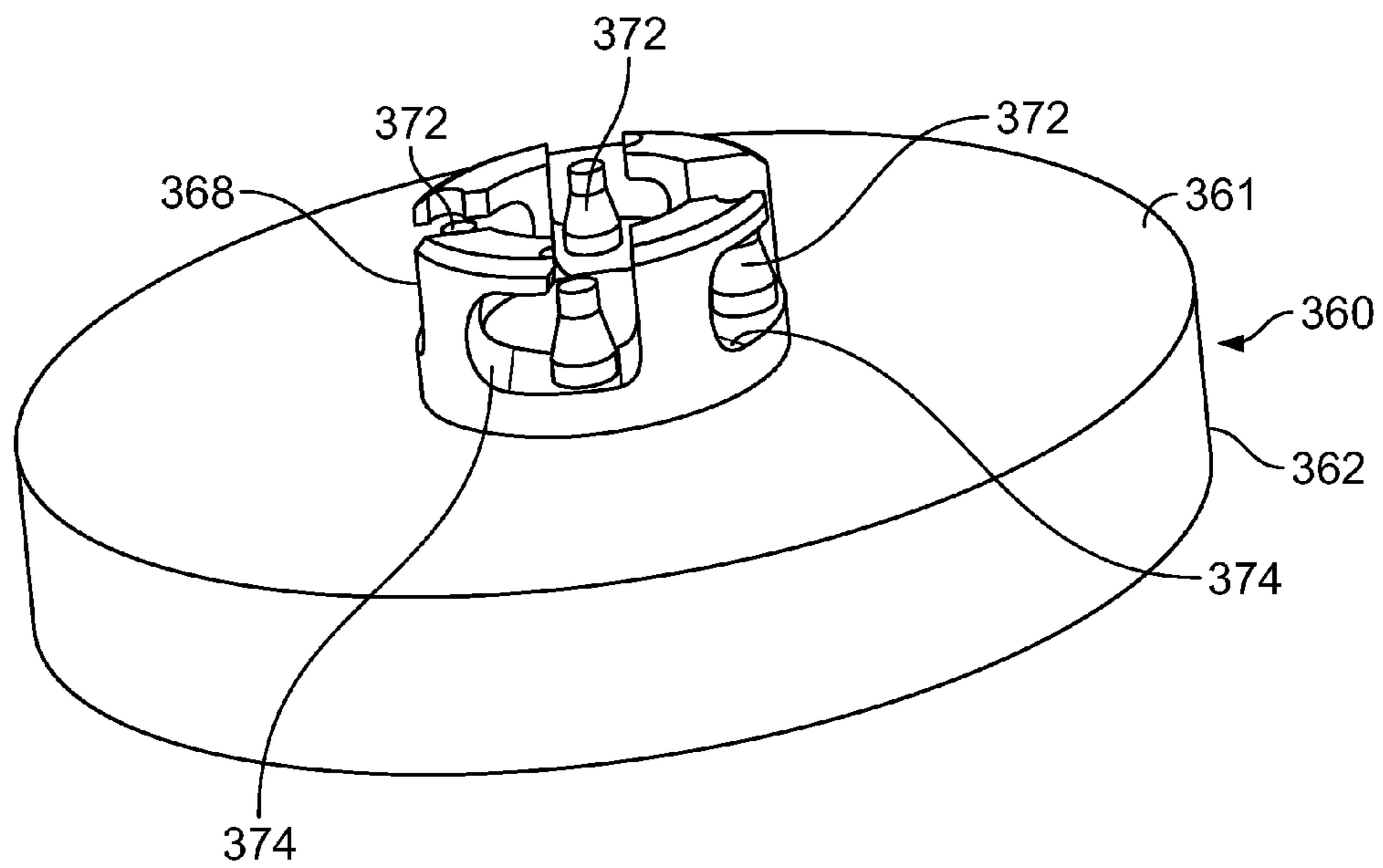


FIG. 4G

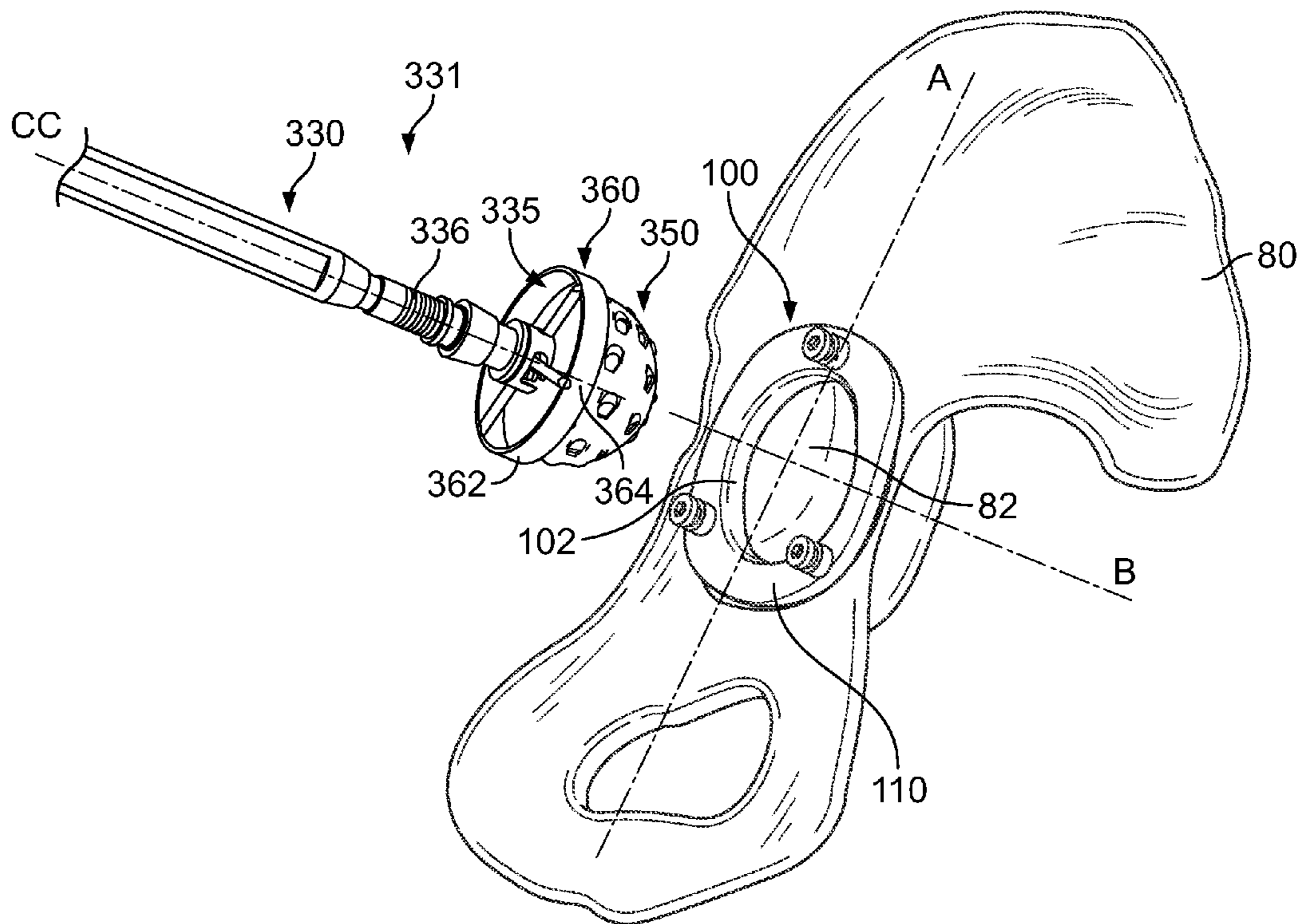


FIG. 4H

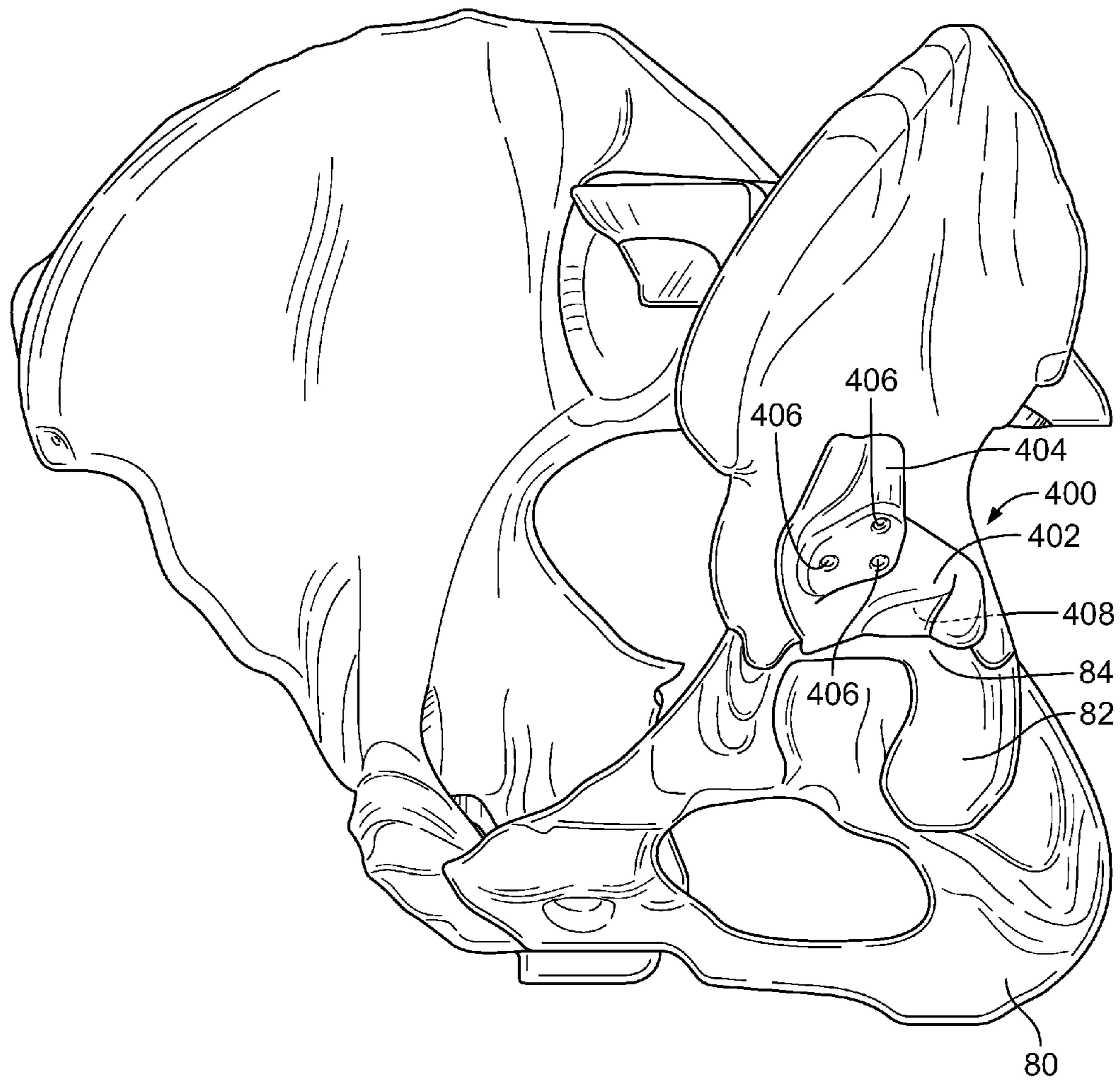


FIG. 5

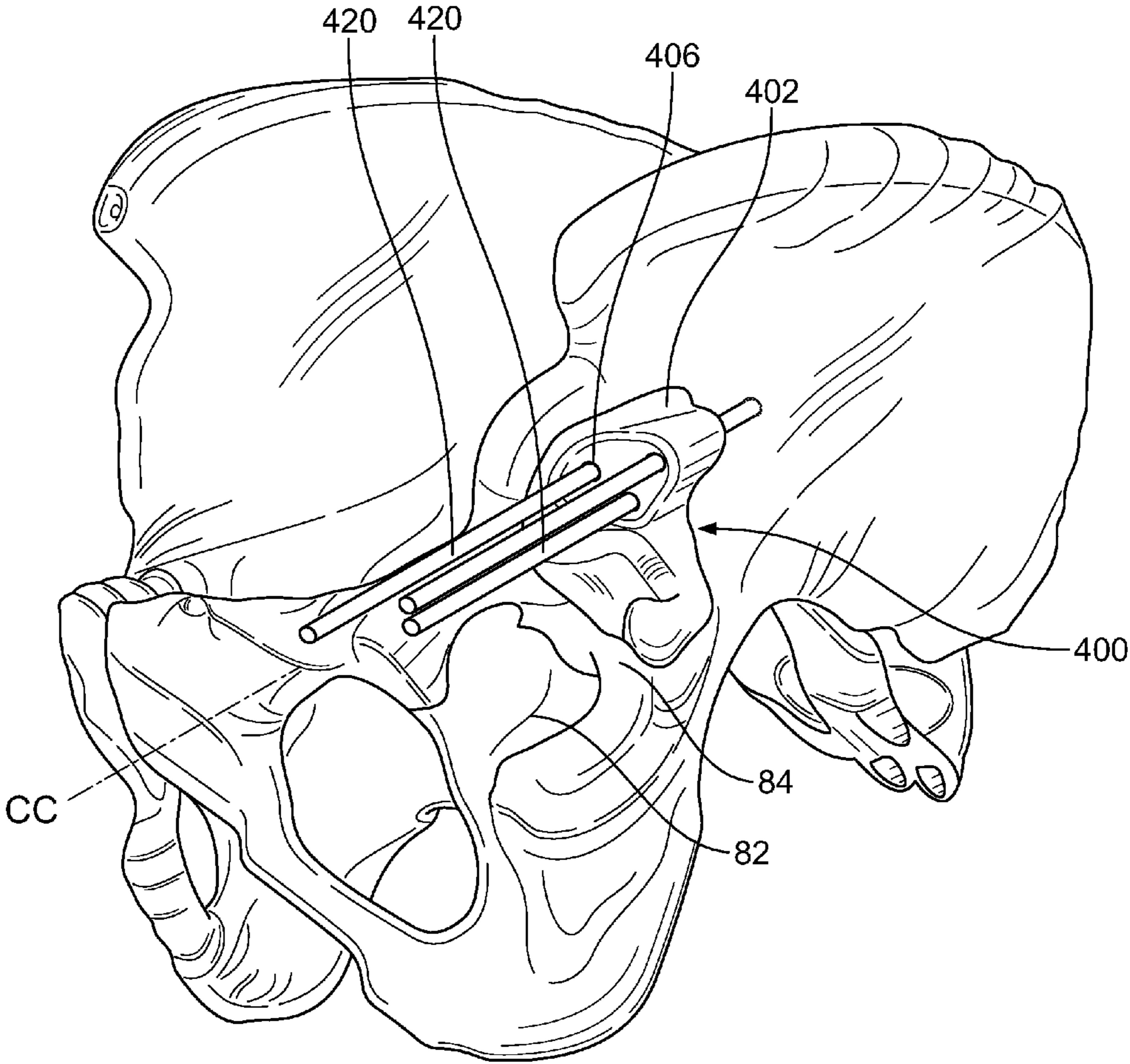
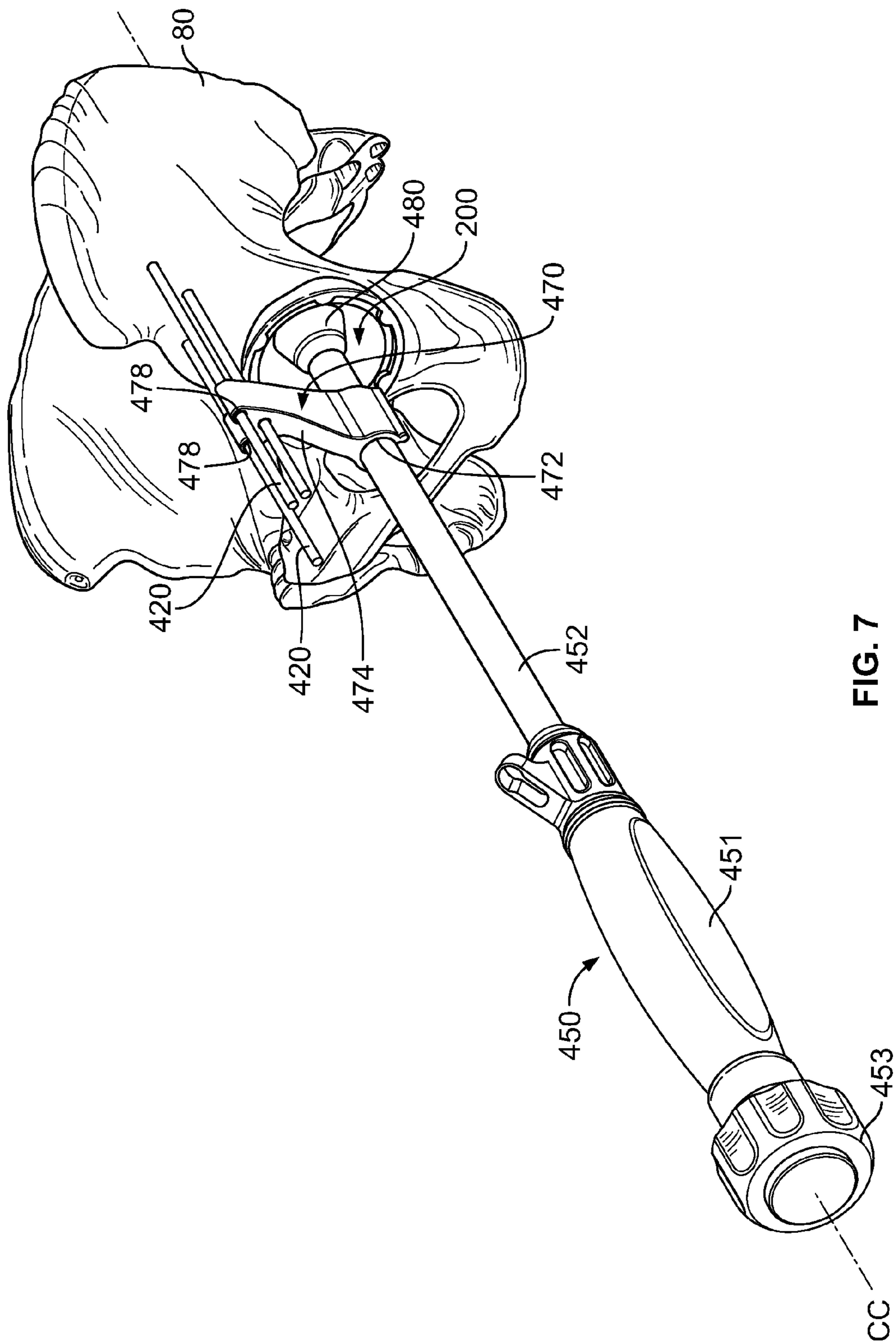


FIG. 6



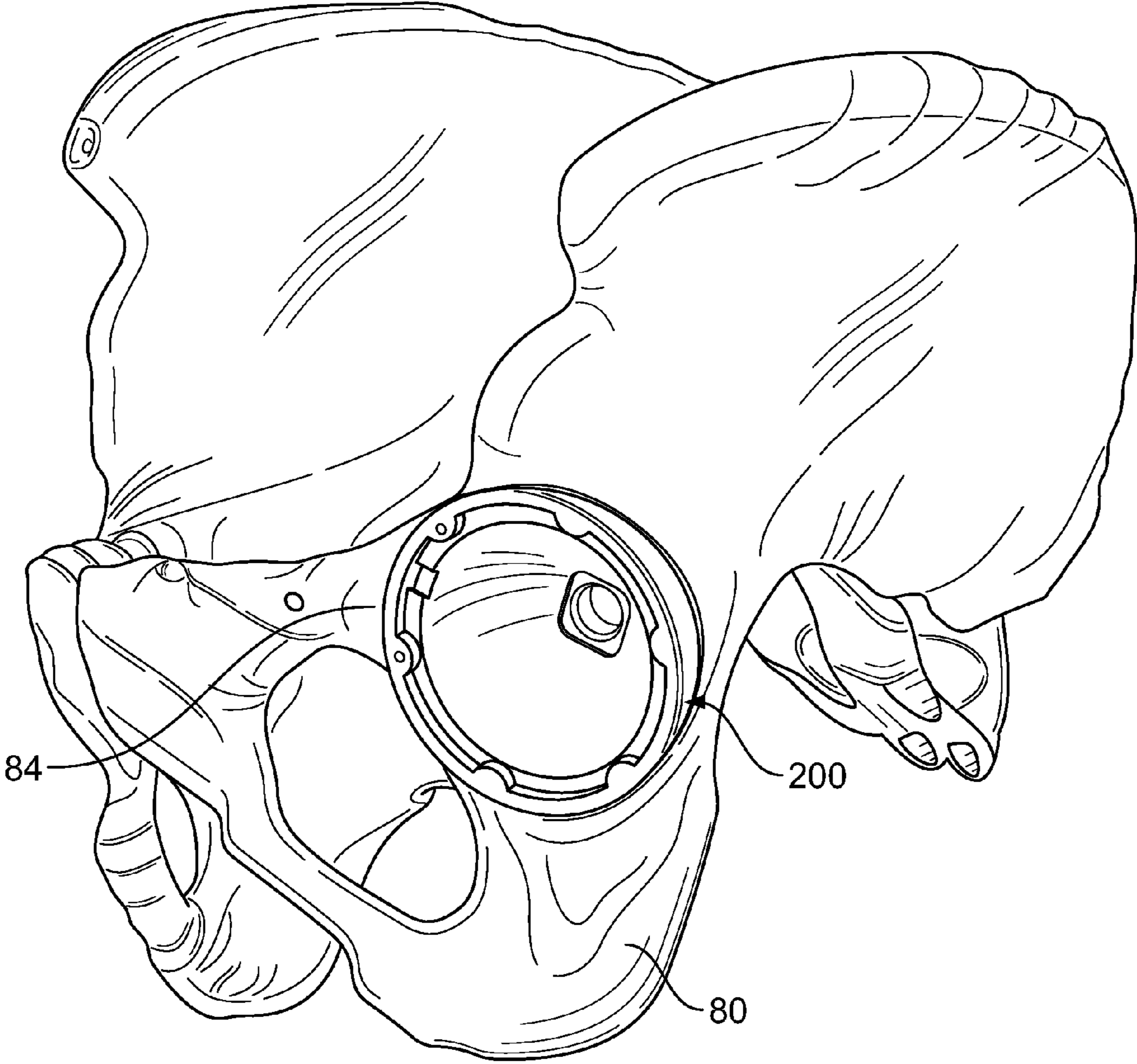
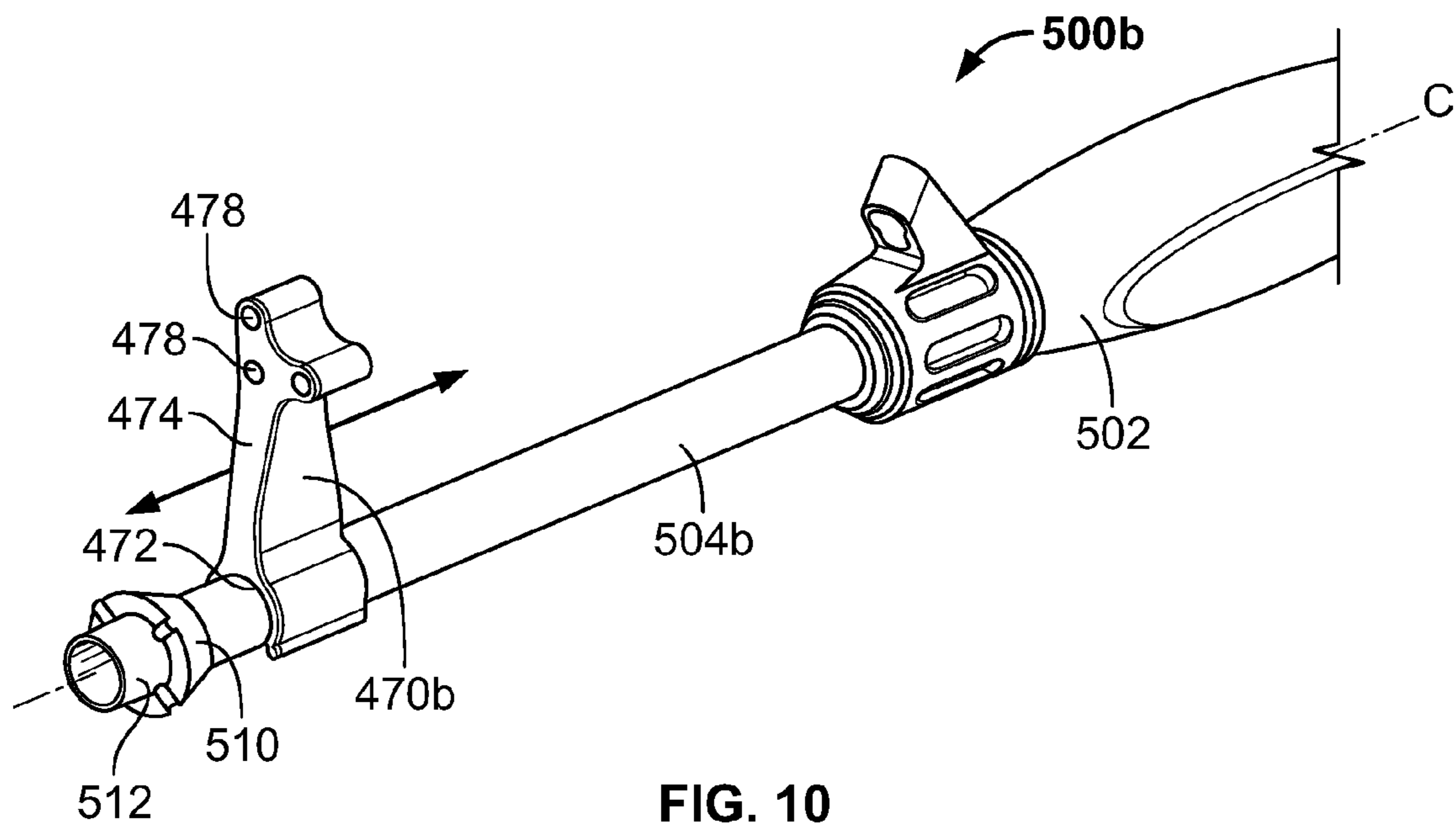
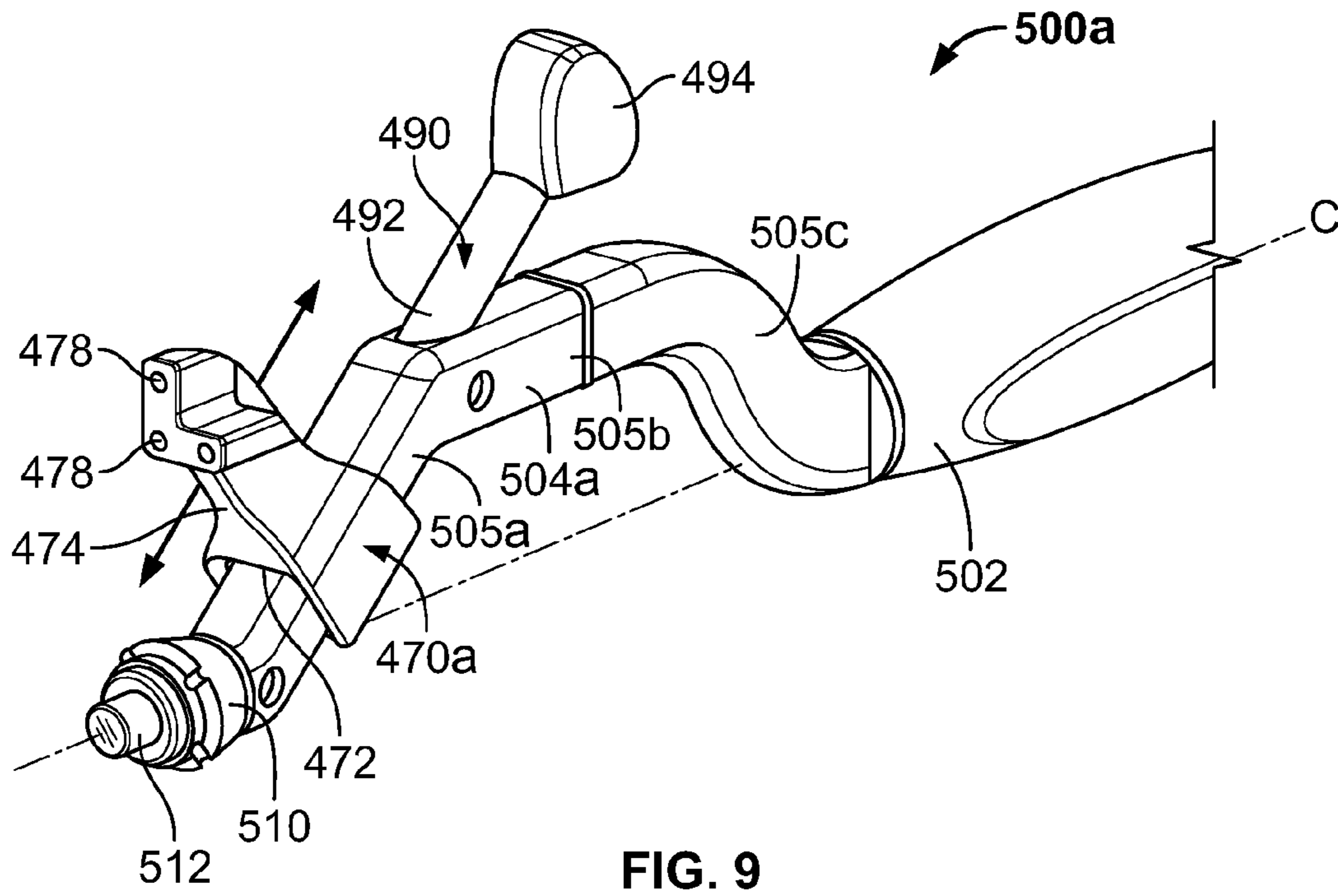


FIG. 8



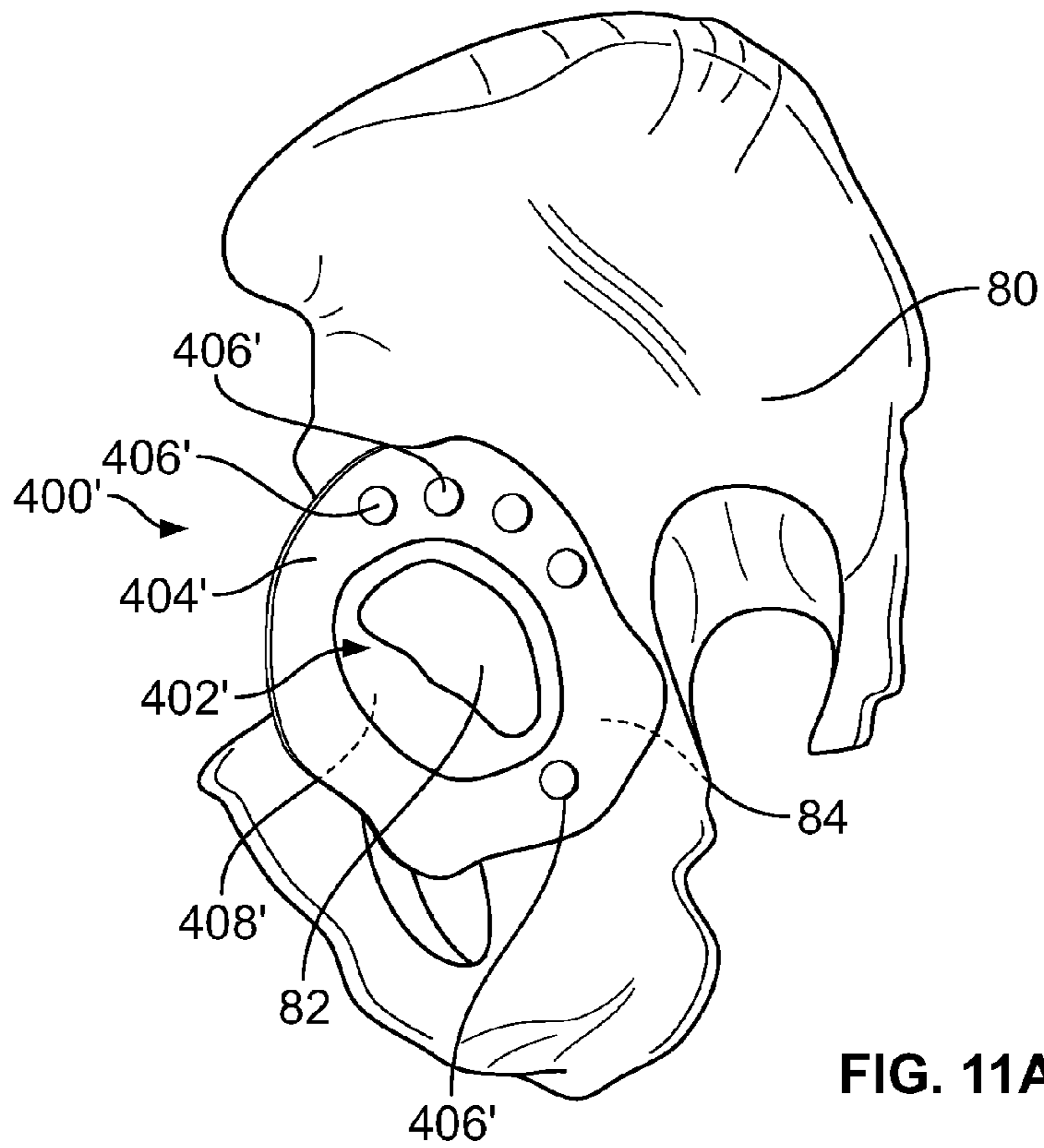


FIG. 11A

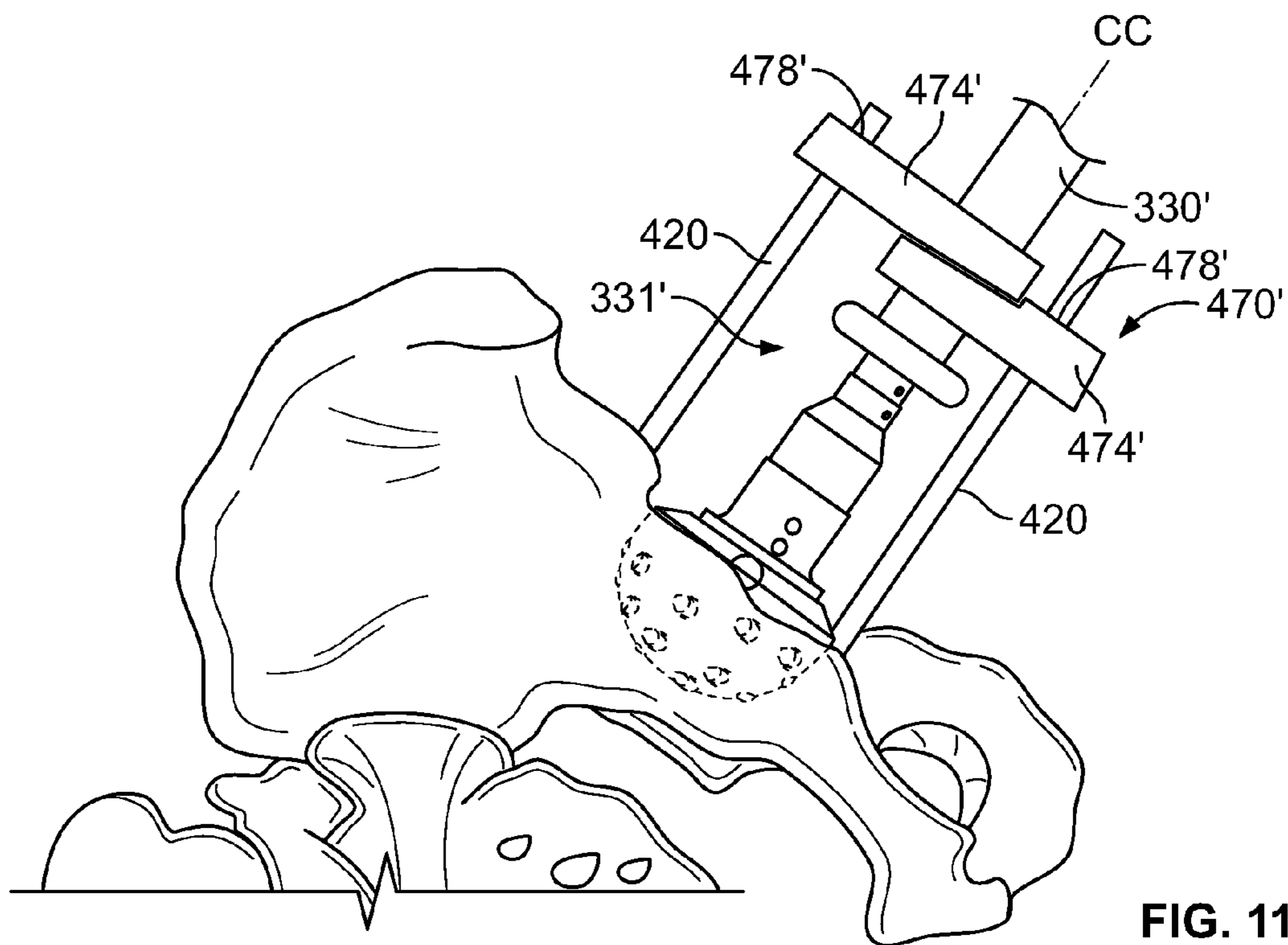


FIG. 11B

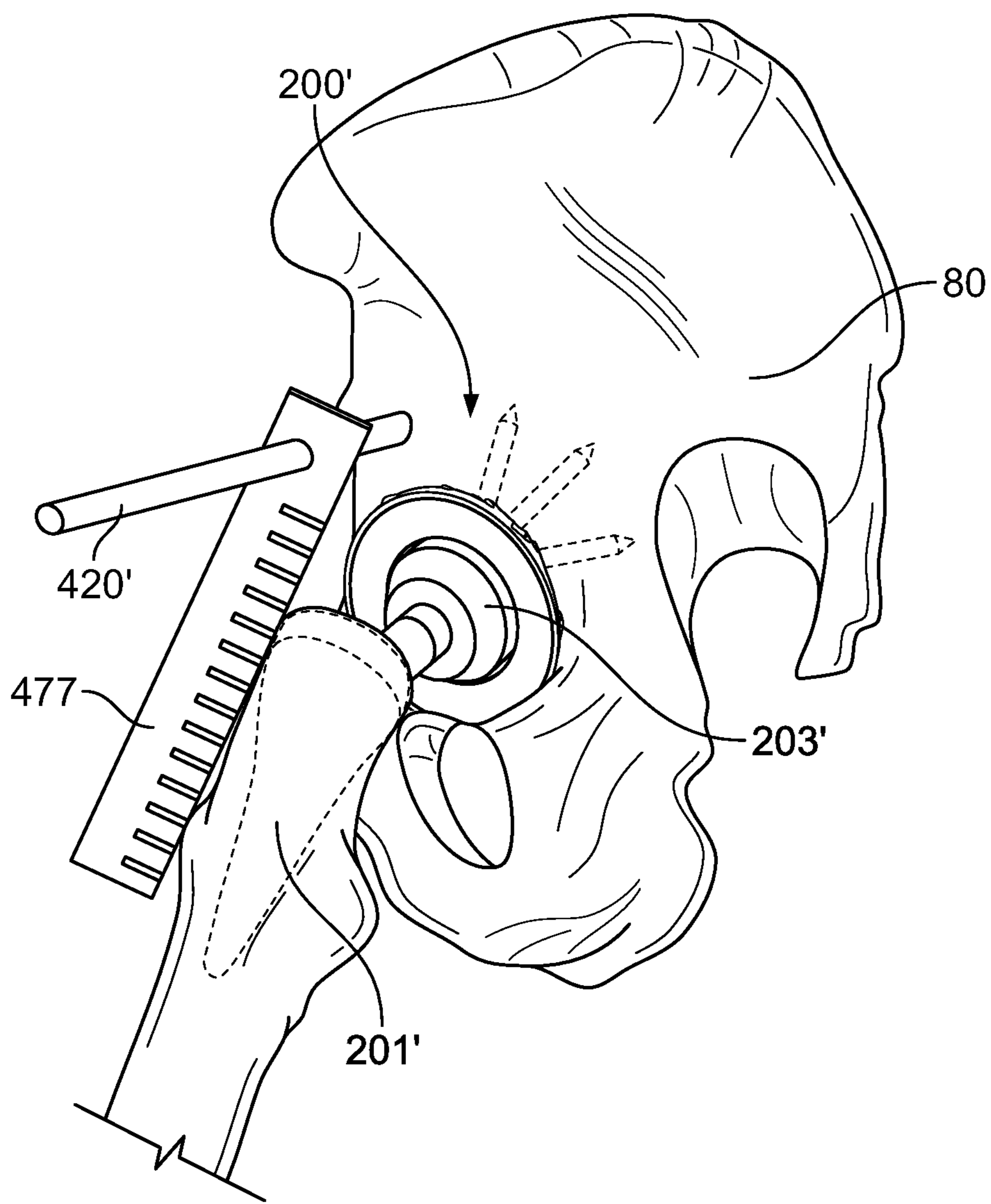


FIG. 11C

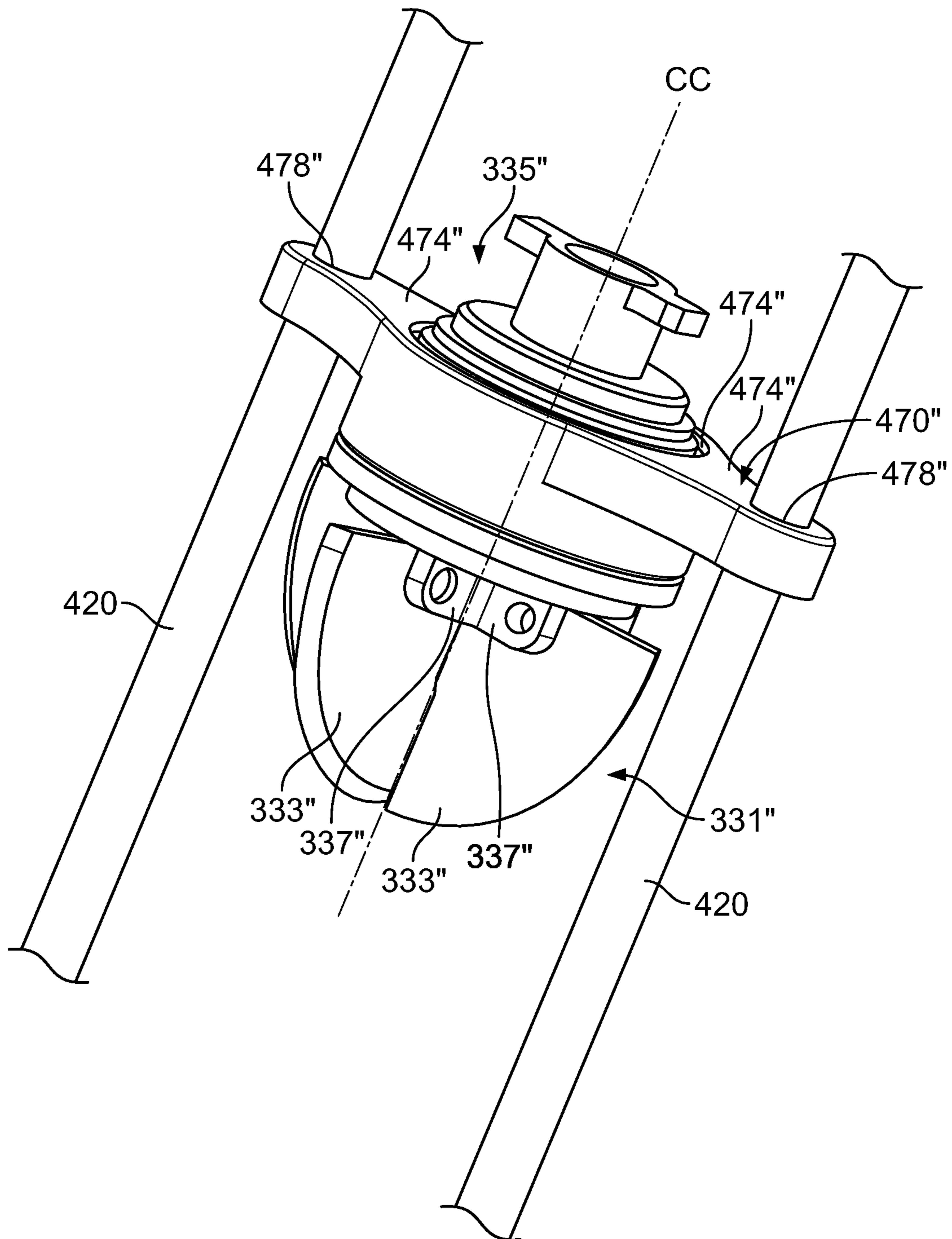


FIG. 12

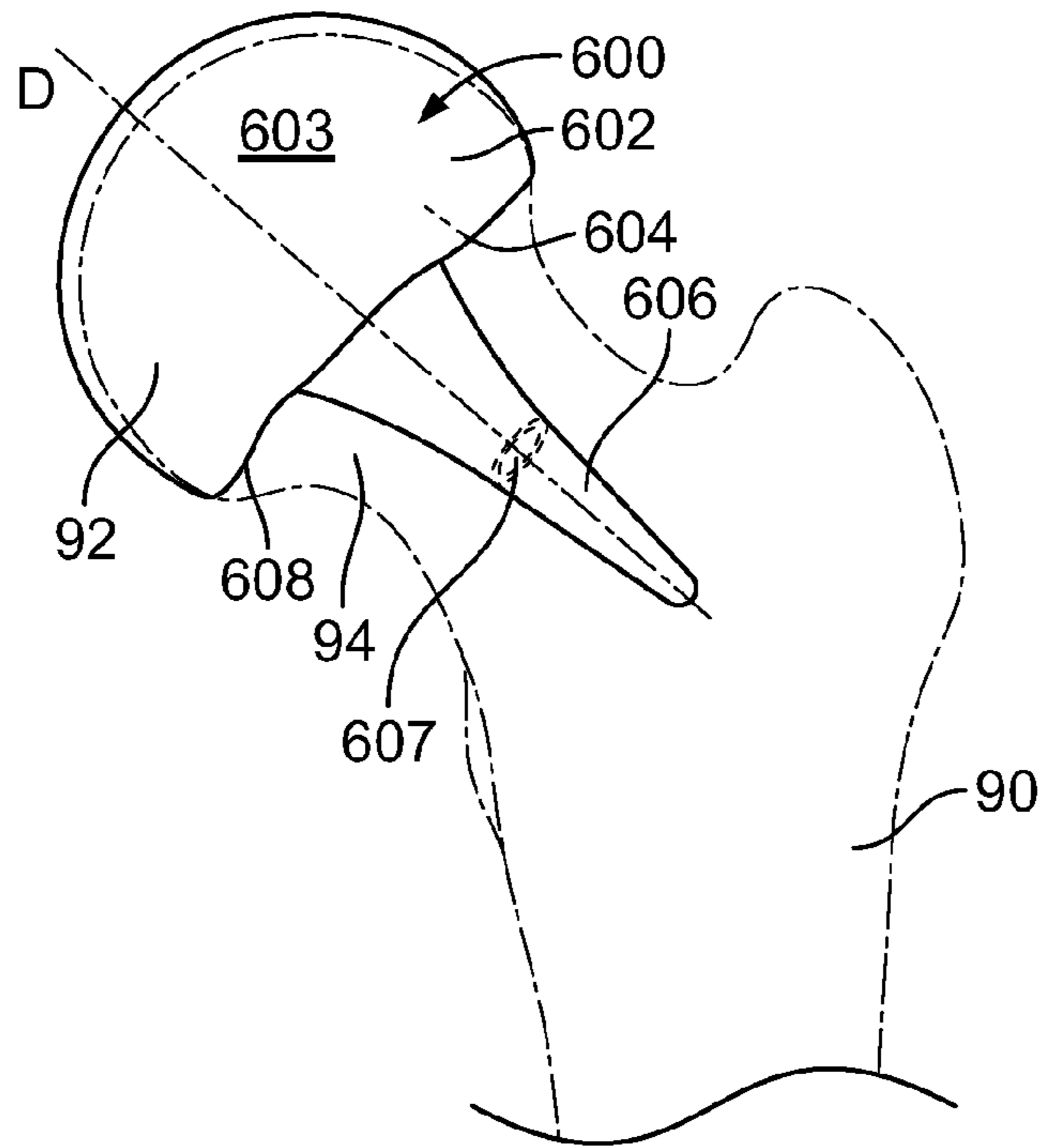


FIG. 13

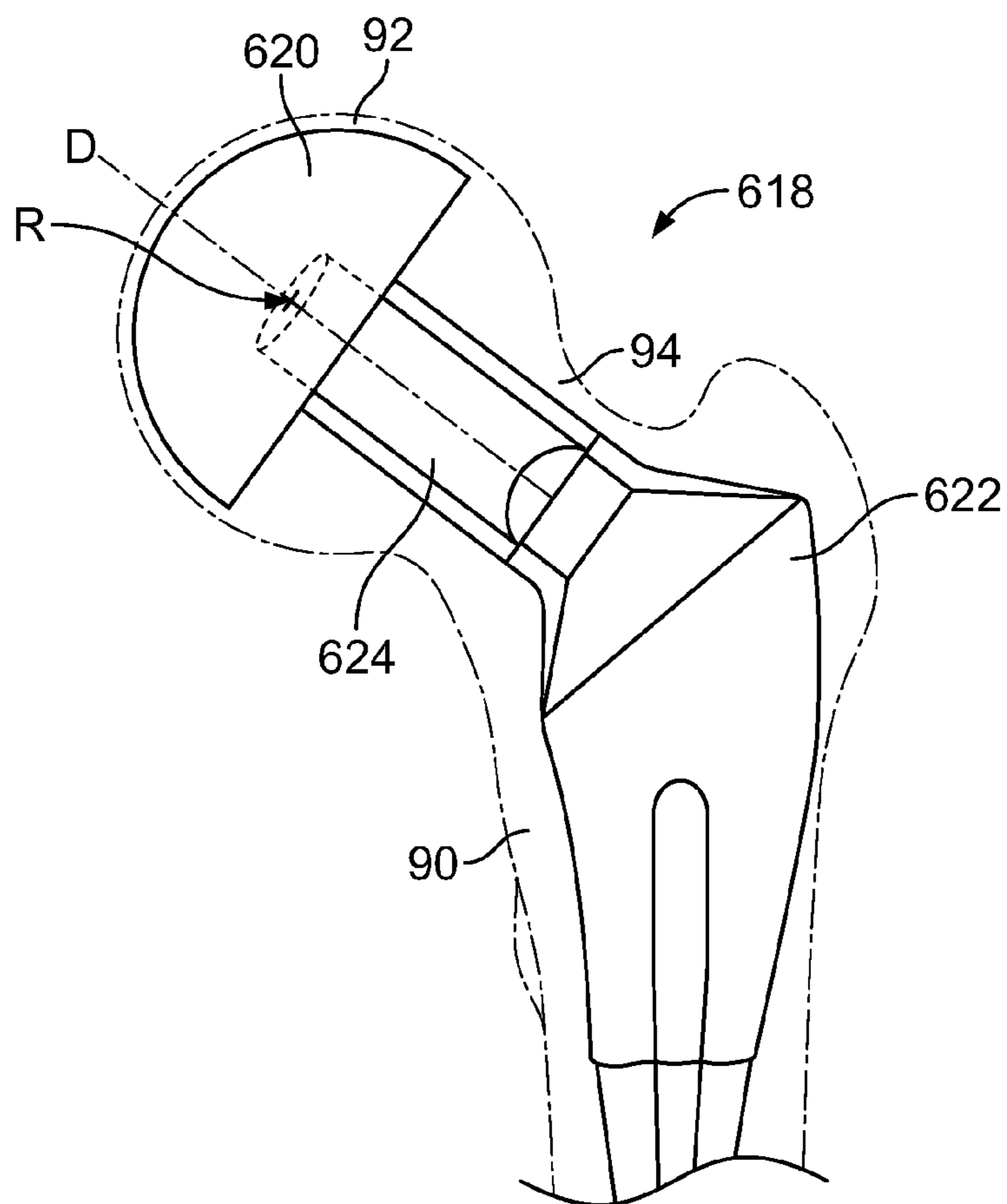


FIG. 14A

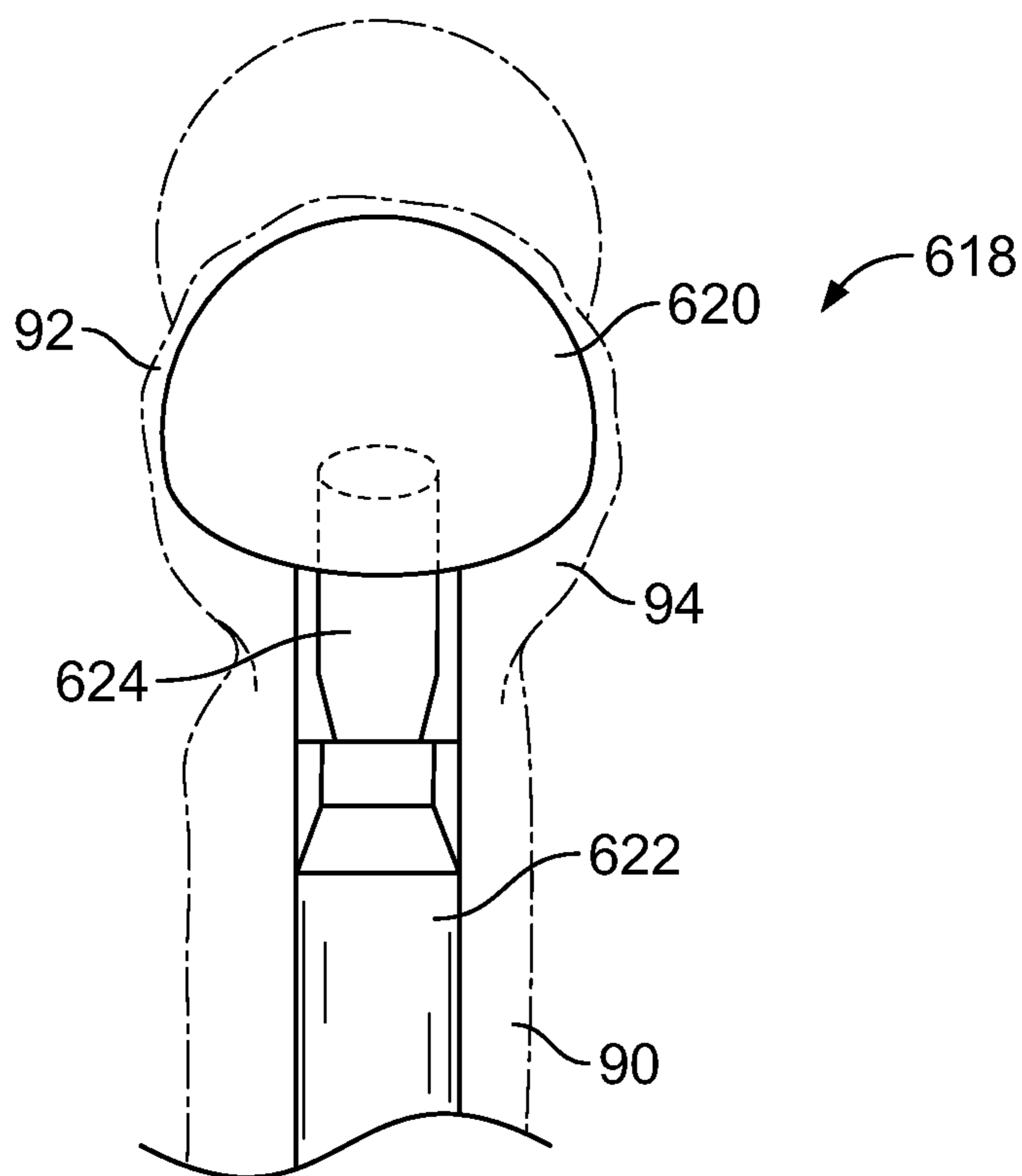


FIG. 14B

1**PATIENT-SPECIFIC ACETABULAR
ALIGNMENT GUIDES****CROSS-REFERENCE TO RELATED
APPLICATIONS**

This application claims the benefit of U.S. Provisional Application No. 61/446,660, filed on Feb. 25, 2011.

This application is a continuation-in-part of U.S. applica-
tion Ser. Nos. 13/041,469, 13/041,495, 13/041,665 and
13/041,883, each filed on Mar. 7, 2011, each of which is a
continuation-in-part of U.S. application Ser. No. 12/978,069
filed Dec. 23, 2010, which is a continuation-in-part of U.S.
application Ser. No. 12/973,214, filed Dec. 20, 2010, which is
a continuation-in-part of U.S. application Ser. No. 12/955,
361 filed Nov. 29, 2010, which is a continuation-in-part of
U.S. application Ser. Nos. 12/938,913 and 12/938,905, both
filed Nov. 3, 2010, each of which is a continuation-in-part of
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which is a continuation-in-part of U.S. application Ser. No.
12/888,005, filed Sep. 22, 2010, which is a continuation-in-
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in-part of U.S. application Ser. No. 12/486,992, filed Jun. 18,
2009, and is a continuation-in-part of U.S. application Ser.
No. 12/389,901, filed Feb. 20, 2009, which is a continuation-
in-part of U.S. application Ser. No. 12/211,407, filed Sep. 16,
2008, which is a continuation-in-part of U.S. application Ser.
No. 12/039,849, filed Feb. 29, 2008, which: (1) claims the
benefit of U.S. Provisional Application No. 60/953,620, filed
on Aug. 2, 2007, U.S. Provisional Application No. 60/947,
813, filed on Jul. 3, 2007, U.S. Provisional Application No.
60/911,297, filed on Apr. 12, 2007, and U.S. Provisional
Application No. 60/892,349, filed on Mar. 1, 2007; (2) is a
continuation-in-part U.S. application Ser. No. 11/756,057,
filed on May 31, 2007, which claims the benefit of U.S.
Provisional Application No. 60/812,694, filed on Jun. 9,
2006; (3) is a continuation-in-part of U.S. application Ser. No.
11/971,390, filed on Jan. 9, 2008, which is a continuation-in-
part of U.S. application Ser. No. 11/363,548, filed on Feb. 27,
2006, now U.S. Pat. No. 7,780,672, issued on Aug. 24, 2010;
and (4) is a continuation-in-part of U.S. application Ser. No.
12/025,414, filed on Feb. 4, 2008, which claims the benefit of
U.S. Provisional Application No. 60/953,637, filed on Aug. 2,
2007.

This application is continuation-in-part of U.S. application
Ser. No. 12/872,663, filed on Aug. 31, 2010, which claims the
benefit of U.S. Provisional Application No. 61/310,752 filed
on Mar. 5, 2010.

This application is a continuation-in-part of U.S. applica-
tion Ser. No. 12/483,807, filed on Jun. 12, 2009, which is a
continuation-in-part of U.S. application Ser. No. 12/371,096,
filed on Feb. 13, 2009, which is a continuation-in-part of U.S.
application Ser. No. 12/103,824, filed on Apr. 16, 2008, which
claims the benefit of U.S. Provisional Application No.
60/912,178, filed on Apr. 17, 2007.

This application is also a continuation-in-part of U.S.
application Ser. No. 12/103,834, filed on Apr. 16, 2008, which
claims the benefit of U.S. Provisional Application No.
60/912,178, filed on Apr. 17, 2007.

The disclosures of the above applications are incorporated
herein by reference.

2**INTRODUCTION**

The present teachings provide a patient-specific acetabular
alignment guide and related instruments for guiding an
acetabular implant into the acetabulum of a patient.

SUMMARY

The present teachings provide an acetabular device. In one
aspect, the acetabular system includes a patient-specific
acetabular alignment guide including a bone engagement sur-
face. The bone engagement surface has a first portion config-
ured and shaped to be conforming and complementary to an
acetabular rim surface and a second portion configured and
shaped to be conforming and complementary to a periac-
etabular area of an acetabulum of a patient. The acetabular
alignment guide includes a plurality of guiding formations
extending through the second portion for guiding a plurality
of alignment pins therethrough. The bone engagement sur-
face and the plurality of guiding formations are prepared from
a three-dimensional model of the acetabulum of the specific
patient reconstructed pre-operatively from a scan of the
patient.

The acetabular device can also include an acetabular
inserter including a handle, a shaft and an acetabular coupler
and a first alignment adapter removably coupled to the shaft
of the acetabular inserter. The first alignment adapter includes
a plurality of apertures configured to correspond to the guid-
ing formations of the acetabular alignment guide, such that
the alignment pins can pass through the apertures of the
alignment adapter after the acetabular alignment guide is
removed without removing the alignment pins from the
patient.

The present teachings also provide a method for inserting
an acetabular implant into the acetabulum of a patient. The
method includes engaging a patient-specific surface of the
acetabular alignment guide to a complementary rim surface
and periacetabular area of a patient and inserting a plurality of
alignment pins through corresponding alignment apertures of
the acetabular alignment guide and into the periacetabular
area of the patient. The method further includes removing the
acetabular alignment guide without removing the alignment
pins from the patient, guiding a first alignment adapter
coupled to an acetabular inserter over the alignment pins, and
implanting the acetabular implant with the acetabular
inserter.

The present teachings provide an acetabular device that
includes an annular acetabular guide including a first surface
and a second surface opposite to the first surface. The first
surface is patient-specific and made to conform to an acetabu-
lar rim surface around an acetabulum of a patient in accord-
ance with a three-dimensional image of the acetabulum of
the patient. The acetabular guide includes a cylindrical inner
guiding surface oriented at patient-specific anteversion and
abduction angles relative to the first surface. The acetabular
device also includes a patient-specific adapter having an outer
surface mateable with the inner surface of the acetabular
guide and having a quick-connection component for coupling
to a non-custom acetabular instrument.

Further areas of applicability of the present teachings will
become apparent from the description provided hereinafter. It
should be understood that the description and specific
examples are intended for purposes of illustration only and
are not intended to limit the scope of the present teachings.

BRIEF DESCRIPTION OF THE DRAWINGS

The present teachings will become more fully understood
from the detailed description and the accompanying draw-
ings, wherein:

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FIG. 1 is an exemplary illustration of a patient in preparation of an acetabular implant procedure;

FIG. 1A is a perspective view of an acetabular guide according to the present teachings, the acetabular guide shown in relation to a patient's anatomy;

FIG. 2 is an environmental perspective view of the acetabular guide of FIG. 1A shown with an acetabular inserter holding an acetabular implant according to the present teachings;

FIG. 3 is a perspective view of the acetabular inserter and acetabular implant of FIG. 2;

FIG. 3A is a perspective environmental view of an acetabular implant illustrating rotation about an anatomic axis A during insertion according to the present teachings;

FIG. 3B is a perspective environmental view of an acetabular implant illustrating rotation about an anatomic axis B during insertion according to the present teachings;

FIG. 4 is an exploded view of the acetabular inserter and acetabular implant of FIG. 3;

FIG. 4A is a perspective view of a modular reamer for use according to the present teachings;

FIG. 4B is bottom plan view of a reamer head of the reamer of FIG. 4A;

FIG. 4C is a perspective view of a reamer driver of the reamer of FIG. 4A;

FIG. 4D is bottom plan view of a distal end of the reamer driver of FIG. 4C;

FIG. 4E is a perspective view of the modular reamer of FIG. 4A shown assembled with a an adaptor for use according to the present teachings;

FIG. 4F is top plan view of the adaptor of FIG. 4E;

FIG. 4G is bottom plan view of the adaptor of FIG. 4E;

FIG. 4H is an environmental view of an assembled of a reamer with a patient-specific adapter according to the present teachings;

FIG. 5 is a perspective environmental view of an exemplary acetabular alignment guide according to the present teachings;

FIG. 6 is a perspective environmental view of the acetabular alignment guide of FIG. 5 shown with a plurality of guiding pins;

FIG. 7 is a perspective environmental view illustrating inserting an acetabular cup with an instrument guided by the guiding pins of FIG. 6;

FIG. 8 is a perspective environmental view of an exemplary acetabular implant;

FIG. 9 is a perspective view of an exemplary impactor according to the present teachings;

FIG. 10 is a perspective view of an exemplary offset impactor according to the present teachings;

FIG. 11A is an environmental view of a patient-specific acetabular guide according to the present teachings;

FIG. 11B is an environmental view of a reamer patient-specific adapter guided for reaming the acetabulum by alignment pins placed using the patient-specific acetabular guide of FIG. 11A;

FIG. 11C is an environmental view of a length scale for measuring a length of an implant, the scale guided by an alignment pin placed using the patient-specific acetabular guide of FIG. 11A;

FIG. 12 is a perspective view of a reamer with a patient-specific adapter guided for reaming the acetabulum by alignment pins placed using the patient-specific acetabular guide of FIG. 11A;

FIG. 13 is an environmental view of a patient-specific resurfacing femoral implant according to the present teachings;

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FIG. 14A is an environmental anterior view of a patient-specific femoral implant according to the present teachings; and

FIG. 14B is an environmental anterior view of the femoral implant of FIG. 14A.

DESCRIPTION OF VARIOUS ASPECTS

The following description is merely exemplary in nature and is in no way intended to limit the present teachings, applications, or uses.

The present teachings generally provide a patient-specific acetabular guide and associated inserter for use in orthopedic surgery, such as in joint replacement or revision surgery, for example. The patient-specific alignment guides can be used either with conventional or patient-specific implant components prepared with computer-assisted image methods. Computer modeling for obtaining three dimensional images of the patient's anatomy using MRI or CT scans of the patient's anatomy, the patient-specific prosthesis components, and the patient-specific guides and templates can be provided by various CAD programs and/or software available, for example, by Materialise USA, Ann Arbor, Mich.

Patient-specific alignment guides and implants are generally configured to match the anatomy of a specific patient. The patient-specific alignment guides are generally formed using computer modeling based on the patient's 3-D anatomic image and have an engagement surface that is made to conformingly contact and match a three-dimensional image/model of the patient's bone surface (with or without cartilage or other soft tissue), by the computer methods discussed above. The patient-specific alignment guides can include custom-made guiding formations, such as, for example, guiding bores or cannulated guiding posts or cannulated guiding extensions or receptacles that can be used for supporting or guiding other instruments, such as drill guides, reamers, cutters, cutting guides and cutting blocks or for inserting pins or other fasteners according to a surgeon-approved pre-operative plan. The patient-specific alignment guides can be used in minimally invasive surgery, and in particular in surgery with multiple minimally-invasive incisions. Various alignment guides and pre-operative planning procedures are disclosed in commonly assigned and co-pending U.S. patent application Ser. No. 11/756,057, filed on May 31, 2007; U.S. patent application Ser. No. 12/211,407, filed Sep. 16, 2008; U.S. patent application Ser. No. 11/971,390, filed on Jan. 9, 2008, U.S. patent application Ser. No. 11/363,548, filed on Feb. 27, 2006; and U.S. patent application Ser. No. 12/025,414, filed Feb. 4, 2008. The disclosures of the above applications are incorporated herein by reference.

As disclosed, for example, in above-referenced U.S. patent application Ser. No. 11/756,057, filed on May 31, 2007; in the pre-operative planning stage for a joint replacement or revision procedure, an MRI scan or a series of CT scans of the relevant anatomy of the patient, such as, for example, the entire leg of the joint to be reconstructed, can be performed at a medical facility or doctor's office. The scan data obtained can be sent to a manufacturer. The scan data can be used to construct a three-dimensional image/model of the joint and provide an initial implant fitting and alignment in a computer file form or other computer representation. The initial implant fitting and alignment can be obtained using an alignment method, such as alignment protocols used by individual surgeons.

The outcome of the initial fitting is an initial surgical plan that can be printed or provided in electronic form with corresponding viewing software. The initial surgical plan can be

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surgeon-specific, when using surgeon-specific alignment protocols. The initial surgical plan, in a computer file form associated with interactive software, can be sent to the surgeon, or other medical practitioner, for review. The surgeon can incrementally manipulate the position of images of implant components in an interactive image of the joint. Additionally, the surgeon can select or modify resection planes, types of implants and orientations of implant insertion. For example, the surgeon may select patient-specific anteversion and abduction angles for acetabular implants, as discussed below. After the surgeon modifies and/or approves the surgical plan, the surgeon can send the final, approved plan to the manufacturer.

After the surgical plan is approved by the surgeon, patient-specific alignment guides can be developed using a CAD program or other imaging software, such as the software provided by Materialise, for example, according to the surgical plan. Computer instructions of tool paths for machining the patient-specific alignment guides can be generated and stored in a tool path data file. The tool path can be provided as input to a CNC mill or other automated machining system, and the alignment guides can be machined from polymer, ceramic, metal or other suitable material, and sterilized. The sterilized alignment guides can be shipped to the surgeon or medical facility, for use during the surgical procedure.

The present teachings provide a patient-specific acetabular guide and associated inserter for inserting an acetabular implant in the acetabulum of a patient's pelvis in a guided orientation at least about first and second non-parallel anatomic axes. Referring to FIGS. 1, 3A and 3B, the first anatomic axis indicated at "A", passes through the acetabulum 82 of a patient's pelvis 80 (only half of the pelvis is shown) and is oriented generally in a superior/inferior direction relative to the patient. The second anatomic axis is indicated at "B" and is substantially perpendicular to the first axis A. As described below, the present teachings provide instruments and methods for guiding, orienting and positioning an acetabular implant 200 at a selected angle of anteversion relative to the axis A, as shown in FIG. 3A, and at a selected angle of abduction relative to the axis B, as also shown in FIG. 3B. The anteversion and abduction angles can be determined interactive or other surgeon input and can be patient-specific.

Referring to FIG. 1A, an exemplary acetabular guide 100 according to the present teachings can include a first surface 108 for engaging an area surrounding the acetabulum 82 and a second surface 110 opposite to the first surface 108. The acetabulum-engaging first surface 108 can be custom-made or patient-specific to conform and mirror an acetabular rim surface 84 around the acetabulum 82 of a specific patient by using three-dimensional image or model of the acetabulum and surrounding pelvic area of the patient, as described above. The first surface 108 enables the acetabular guide to nest or closely mate relative to the acetabulum 82 of the patient.

The acetabular guide 100 can be temporarily and removably attached to the pelvis 80 using temporary fasteners 120, such as bone nails or tacks, for example, passing through corresponding holes 104 through the acetabular guide 100. The acetabular guide 100 can be annular with an opening defined by an inner surface 102. The inner surface 102 can be, for example, a cylindrical surface. The inner surface 102 can be oriented relative to the first and second surfaces 108, 110 of the acetabular guide 100 to provide a selected anteversion angle about the first axis A and a selected abduction angle relative to the axis B, as shown in FIGS. 2, 3A and 3B. The anteversion and abduction angles can be surgeon-selected and patient-specific and can be determined with surgeon

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input during the pre-operative planning for the specific patient. Anteversion angles can be, for example, in the range of about 10-20 degrees forward relative to the first axis A, and adduction angles can be in the range of about 40-50 degrees downward relative to the second axis B.

Referring to FIGS. 2-4, the acetabular guide 100 can be attached to the pelvis 80 around the acetabulum 72 after the acetabulum 82 has been reamed and prepared for receiving the acetabular implant 200, such as the Magnum™ acetabular cup commercially available from Biomet, Inc., Warsaw, Ind. The acetabular implant 200 can be inserted into the prepared acetabulum 82 using an inserter 300 according to the present teachings. The inserter 300, which can also function as an impactor, can include a handle 304 with a proximal impactation surface 318, a shaft 302 and a guide-engaging portion 310 having a surface with a flat or planar portion 320. The guide-engaging portion 310 can have an outer surface 312, which conforms to and is mateable with the inner surface 102 of the acetabular guide 100 for guiding the acetabular implant 200. The inner surface 102 and the outer surface 312 can be cylindrical.

Referring to FIG. 4, the inserter 300 can engage the acetabular implant 200 via an intermediate member 250, such as the intermediate member of the Magnum™ system, which is commercially available from Biomet, Inc., Warsaw, Ind. More specifically, the inserter 300 can include a distal portion 314, such as a ball-bearing bushing, which can be inserted and engage a receptacle 252 of the intermediate member 250. The acetabular implant 200 can be mounted on the inserter 300 by aligning a plurality of fingers 254 of the intermediate member 250 with corresponding cut-outs 202 on a peripheral edge of the acetabular implant 200. The acetabular implant 200 can be secured to the inserter 300 by rotating the acetabular implant 200 relative to the insert 300 until a hand-tight fit is obtained.

Referring to FIG. 2, the inserter 300 with the acetabular implant 200 mounted thereon can be directed toward the acetabular guide 100. The outer surface 312 of the guide engaging portion 310 of the inserter 300 can be brought into contact with the inner surface 102 of the acetabular guide 100, guiding the acetabular implant 200 toward the selected anteversion and abduction orientation through the acetabular guide 100. The outer surface 312 of the guide engaging portion 310 can also provide an impactation-depth feedback by alignment with the inner surface 102 of the acetabular guide. Full impactation of the acetabular implant 200 into the acetabulum 82 can be indicated when planar portion 320 and/or outer surface 312 of the guide-engaging portion 310 of the inserter 300 are flush with and do not protrude over and above the second surface 110 of the acetabular guide 100. Depth indicia 322 can also be provided on the inserter shaft 302 or on the guide-engaging portion 310 of the inserter 300, as shown in FIG. 2.

After the acetabular implant 200 is fully seated in the acetabulum 82 in the selected anteversion and abduction orientations, the inserter 300 and intermediate member 250 can be removed. The temporary fasteners 120 can be removed and the acetabular guide released.

The acetabular guide 100 can be made of any biocompatible material, such as metal, ceramic or polymer. The acetabular guide 100 can be constructed by various manufacturing methods depending of the selected material, including, for example, machining, casting, molding, stereolithography or other layer deposition methods. In one aspect, the acetabular guide 100 can be made of disposable plastic material.

The patient-specific acetabular guide 100 can also be used with a standard (non patient-specific) modular reamer 331 fitted with a patient-specific reamer adapter 360 to ream the

acetabulum of the specific patient in pre-planned patient-specific orientations. This allows the acetabular implant 200 to be received in the selected anteversion and abduction orientations, as shown in FIG. 4H and discussed in connection with FIGS. 4A-4H.

FIGS. 4A-4C illustrate an exemplary modular reamer 331 that includes a reamer driver 330 and a reamer head 350. The reamer driver 330 can be removably coupled to the reamer head 350 with a connecting mechanism 335, which can be a spring-loaded, or snap-fit or other type of releasable connection, including connections secured with a set screw or other easily removable fasteners. An exemplary quick-connect connection is illustrated in FIGS. 4A-4D and is also used to connect the reamer 331 to the reamer adapter 360, as illustrated in FIGS. 4E-4H.

The reamer head 350 can be in the form of a hollow cup with a semi-spherical reaming surface 353 bounded by a periphery 351. The reaming surface 353 defines a plurality of reaming formations or reaming teeth 357. A number of arms or rods 342 can be connected to the periphery 351 and form a first component of the quick-connect mechanism 335. The arms 342 can be attached to one another at a central hub 341 forming a frame 343, as shown in FIG. 4B.

The reamer driver 330 can include a handle or sleeve 332 receiving a driver shaft 334 for coupling to a driver tool at a proximal end (not shown) and having a distal connector 338. The distal connector 338 forms a second component of the quick connect mechanism 335, which is operated with a spring-loaded slider or trigger 336 coupled to the driver shaft 334. The distal connector 338 can include a number of openings or slots 344 and a corresponding number of movable or retractable pins 346. The number of slots 344 corresponds to the number of arms 342 and the slots 344 are sized and shaped to receive the arms 342. Although four arms, slots and pins are illustrated, a smaller or greater number can be used, for example two or three arms, slots and pins that can be evenly positioned radially about the reamer head 350. To connect the reamer driver 330 to the reamer head 350, the slots 344 are placed over the arms 342 with the pins 344 in their retracted position. The pins 344 can be retracted by moving the slider 336 in a direction away from the distal connector 338. When the slider 336 is released, the arms 342 are gripped between the pins 344 and the walls of the slots 344 and the reamer driver 330 is securely connected to the reamer head 350.

Referring to FIGS. 4E-4H, the patient-specific reamer adapter 360 can include a first portion 362 and a second portion 368. The first portion 362 can have an outer surface 364. The outer surface 364 can be, for example, cylindrical. The outer surface 364 can be shaped, sized and oriented to mate with the inner surface 102 of the patient-specific guide 100 to provide a selected and patient-specific anteversion angle about the first axis A and a selected abduction angle relative to the axis B, as shown FIG. 4H. In this respect, the outer surface 364 of the adapter 360 is patient specific.

The reamer adapter 360 can be coupled to the reamer with a quick-connect connection. For example, the reamer adapter 360 can be coupled between the reamer driver 330 and the reamer head 350 with corresponding components of the quick-connect mechanism 335 used for the connecting the reamer driver 330 to the reamer head 350. Referring to FIGS. 4E-4H, the first portion 362 can include a number of arms 370 coupled to a proximal periphery 363 of the first portion 362 and are configured to engage the distal connector 338 of the reamer driver 330, i.e. to be gripped in corresponding slots 344 by corresponding pins 346. In this regard, the arms 370 of the first portion 362 provide a component that is complemen-

tary to the quick-connect component of the reamer driver 330 and complete a quick-connect mechanism 335 between the reamer driver 330 and the reamer adapter 360.

Similarly, the second portion 368 of the reamer adapter 360 can include a quick-connect component complementary to the quick-connect component of the reamer head 350 to complete the quick-connect mechanism 335. More specifically, the second portion 368 can include a number of slots 374 and pin 372 for gripping the arms 342 of the reamer head 350. Accordingly, the same type of quick-connect mechanism 335 that is used to couple the reamer driver 330 to the reamer head 350 can be used to couple the reamer adapter 360 between the reamer driver 330 and the reamer head 350, as illustrated in FIGS. 4A and 4E. It is noted that the quick-connect mechanism 335 is not limited to the exemplary embodiment illustrated, but can be any quick-connect mechanism used for non-patient-specific modular reamers, include snap-fit, tapered connectors, threaded connectors, or any other connectors with complementary components "a" for the reamer driver 330 and "b" for the reamer head 350, which are then used in reverse order to couple the reamer adapter 360 therebetween in a sequence a-b-a-b. In the illustrated quick-connect mechanism 335, component "a" includes slots and pins and component "b" includes arms.

Referring to FIG. 4H, the assembled reamer 331 with the patient-specific adapter 360 can be used with the patient-specific acetabular guide 100 to ream the acetabulum 82 of the patient to receive an implant in a selected patient-specific orientation according to the pre-operative plan. As described above in relation to FIGS. 1-4, the acetabular guide 100 is attached to the acetabulum 82 in only one position, such that the inner surface 102 provides an orientation guide for the reamer head 350. In particular, the outer surface 364 of the reamer adapter 360 mates in a complementary close-fit manner with the inner surface 102 of the acetabular guide 100, such that the reamer head 350 can be oriented as specified in the pre-operative plan to ream the acetabulum in the selected anteversion and abduction orientations relative to the corresponding axes A and B. After the acetabulum 82 is reamed, the acetabular implant 200 can be impacted in the same selected orientation using the inserter/impactor 300 discussed in connection with FIGS. 2 and 3.

The exemplary acetabular guide 100 illustrated in FIGS. 1A, 2 and 4H is annular for placement around the acetabulum 82. In other embodiments, an acetabular guide 400 positioned only in a portion around the acetabulum 82 can also be used. Referring to FIGS. 5-10, the patient-specific acetabular alignment guide 400 and other instruments for guiding an acetabular implant are illustrated. The patient-specific acetabular alignment guide 400 can be prepared during a pre-operative plan for the surgical procedure based on a three-dimensional image of the relevant anatomy of the patient including portions of the pelvis 80, the acetabulum 82, the acetabular rim area 84, the periacetabular area and generally the hip joint of the patient. The three-dimensional image of the anatomy of the patient can be developed by commercially available software, as discussed above, using MRI, CT, X-rays or other scans of the particular patient.

Referring to FIGS. 5 and 6, the acetabular alignment guide 400 can include a first portion 402 configured and adapted to be positioned around the rim surface 84 of the acetabulum 82 and a second portion 404 configured and adapted to be positioned around the periacetabular area of the pelvis 80 of a specific patient. The acetabular alignment guide 400 can include a three-dimensional curved patient-specific bone engagement surface 408. The bone engagement surface 408 is defined to match complementarily to a portion of the

acetabular rim surface **84** and a portion of an adjacent periacetabular area of the pelvis **80** of the patient for close contact/nesting thereon in only one position and orientation. The second portion **404** of the acetabular alignment guide **400** is designed during the pre-operative plan to define a plurality of elongated through-slots, apertures or other guiding formations **406** directed toward the periacetabular area for guiding a plurality of alignment pins **420** parallel to an acetabular centering axis CC, the location and orientation of which is determined according to the preoperative plan for the specific patient. The second portion **404** can be reinforced with additional materials and/or have thicker dimensions for stability.

Three guiding formations **406** in the form of through holes and a corresponding number of alignment pins **420** are illustrated in FIGS. **5** and **6**. Depending on the patient and/or procedure, a different number of guiding formations **406** and alignment pins **420** can be used. The alignment pins **420** can be parallel defining a patient specific orientation and operable for locating the acetabular centering axis CC. The alignment pins **420** can removably guide along the same axis other instruments associated with the insertion of an acetabular implant **200** after the acetabular alignment guide **400** is removed, as shown in FIG. **7**, for example. The orientation and location of the guiding formations **406** can be patient-specific and determined pre-operatively to facilitate guiding and supporting the various instruments used for positioning, inserting and impacting the acetabular implant **200**, as discussed below.

Referring to FIG. **7**, after the alignment pins **420** have been inserted into the bone, the acetabular alignment guide **400** can be removed. An acetabular positioner or inserter or inserter/impactor **450** can be guided by the alignment pins **420** for inserting the acetabular implant **200** in the acetabulum. The inserter **450** can include a handle **451** with a knob **453** and a shaft **452** coupled to a patient-specific alignment adapter **470**. The patient-specific alignment adapter **470** can include an arm **474** defining a plurality of alignment apertures **478** complementary to the alignment pins **420**, such that the alignment adapter **470** can removably slide over the alignment pins **420**. In this respect, the shape and size of the arm **474** and the placement, arrangement and configuration of the alignment apertures **478** can be determined during the pre-operative plan to correspond to the guiding formations **406** of the acetabular alignment guide **400**. The alignment adapter **470** can include a coupling opening **472** for removably receiving the shaft **452** of the inserter **450** or can be integrally coupled to the shaft **452** of the inserter **450**. The coupling opening **472** can be, for example, an interference fitting or snap-on side slot. Alternatively, the coupling opening **472** can be an enclosed hole, which receives the shaft **452** of the inserter **450**, when the shaft is modularly coupled to the inserter **450**. The inserter **450** can be connected to and disconnected from the acetabular implant **200** with a coupler **480** at the distal end of the shaft **452** by rotating the knob **453**. The coupler **480** can also be modularly connected to the shaft **452**. During insertion of the acetabular implant **200**, the alignment pins **420** help stabilize, guide and secure the orientation of the inserter/impactor **450** and acetabular implant **200** and place the acetabular implant **220** in the desired position and orientation relative to the acetabulum **82** as determined during the pre-operative plan using imaging scans of the patient.

Similar patient-specific alignment adapters **470** can be used for guiding other type of inserters or impactors or reamers with reamer driver handles or other instruments, such as, for example, reamers and impactors that can be used during the preparation and implantation procedure. Referring to FIGS. **9** and **10**, first and second impactors (or other acetabu-

lar instruments) **500a**, **500b** are illustrated with respective first and second patient-specific alignment adapters **470a**, **470b**. The first impactor **500a** is an offset impactor **500a** generally used for minimally invasive procedures, and the second impactor **500b** is straight, non-offset impactor. Each of the first and second impactors **500a**, **500b** can be modular and include a handle **502** respectively coupled to a first shaft **504a** or second **504b** terminating at a coupler **510** with an end connector **512**. The first shaft **504a** of the first impactor **500a** is offset relative to a longitudinal axis C (designed to coincide with the acetabular centering axis CC) passing through the handle **502** and the end connector **512**. The shaft **504b** of the second impactor **500b** is coaxial with the handle **502**.

As illustrated in FIG. **9**, the offset first shaft **504a** can include a center portion **505c** offset and substantially parallel to the longitudinal axis C and first and second end portions **505a**, **505b** angled relative to the center portion **505c** for defining the offset. The first end portion **505a** can be cannulated or hollow for receiving a shaft **492** of a driver **490** coupled to the end connector **512**, such that the end connector **512** can be secured to the acetabular implant **200** by rotating a knob **494** of the driver **490**. The first alignment adapter **470a** includes a coupling opening **472** (enclosed hole or side opening/slot) through which the portion **505a** can pass through. As discussed above in connection with alignment adapter **470** and the inserter **450** of FIG. **7**, the shape and size of the arm **474** and the placement and arrangement/configuration of the alignment apertures **478** can be determined during the pre-operative plan to correspond to the guiding formations **406** of the acetabular alignment guide **400** and the location and orientation of the alignment pins **420**, such that the parallel alignment pins **420** can pass through the parallel alignment apertures **478** to guide the first impactor **500a** relative to the acetabular implant **200** and relative to the acetabulum **82**. The first alignment adapter **470a** can be removably coupled to the first impactor **500a** and can be slidably adjusted in position relative to the first portion **505a** while maintaining the alignment orientation of the alignment apertures **406** relative to axis CC and the alignment pins **420**.

Referring to FIG. **10**, the second impactor **500b** can be used similarly. Because the shaft **504b** is substantially straight (not offset), the end connector **512** can be attached to the acetabular implant **200** by simply rotating the handle **502** or a knob attached to the handle (not shown), similarly to the inserter **450** shown in FIG. **7**. Each impactor **500a**, **500b** can be modular, such that the handle **502**, the shaft **504a**, **504b** and/or the coupler **510** can be disassembled for removably mounting the alignment adapter **470a**, **470b**. Additionally, or alternatively, the coupling opening **472** can be a snap-on side opening or side slot for removably receiving the alignment adapter **470a**, **470b** without disassembling the impactor **500a**, **500b**.

In some embodiments, the same alignment adapter can be used for more than one conventional acetabular instrument. For example, the same the alignment adapter **470** (or **470b**) can be used optionally either with the inserter/impactor **450** or the impactor **500b**, or with an acetabular reamer, such as reamer **331**.

It will be appreciated from the above discussion, that although the patient-specific acetabular alignment guide **400** has an engagement surface **408** that is complementary to the acetabular/periacetabular area of the patient, the alignment adapters **470**, **470a** and **470b** may or may not have a patient-specific engagement surface as they are at a distance away from the bone surface during use. Rather, the location and arrangement of the alignment apertures **478** on the arm **474** is patient-specific, such that the corresponding alignment adapter **470**, **470a**, **470b** can be mounted over the plurality of

the alignment pins **420** that have been already secured around the acetabulum **82** of the patient using acetabular alignment guide **400**.

The acetabular alignment guide **400** and the alignment adapters **470**, **470a**, **470b** can be made of disposable polymeric materials or any other biocompatible materials. The alignment adapters **470**, **470a**, **470b** can be used with acetabular inserters, positioners, reamers, impactors and other instruments used during the acetabular procedure. The acetabular alignment guide **400** and one or more alignment adapters **470** can be provided in a form of a kit with a set of alignment pins **420**. Other reusable, non custom instruments can be also included, for example, an inserter, reamer impactor, etc. The kit can include an acetabular implant **200**, which can be custom-made or non custom-made, as approved and selected by the surgeon.

Referring to FIGS. **11A** to **12**, another patient-specific acetabular guide **400'** is illustrated for use with a reamer **331'**. As discussed above in connection with acetabular guides **100** and **400**, the acetabular guide **400'**, can include a first portion **402'** configured and adapted to be positioned around the rim surface **84** of the acetabulum **82** and a second portion **404'** configured and adapted to be positioned around the periacetabular area of the pelvis **80** of a specific patient. The acetabular alignment guide **400'** can include a three-dimensional curved patient-specific bone engagement surface **408'**, which is the underside surface of the first and second portions **402'**, **404'** that nestingly mates with the specific patient's anatomy. In the exemplary embodiment illustrated in FIG. **11A**, the first portion **402'** can extend around the entire inner rim surface **84** of the acetabulum and at least a portion of the acetabulum **82**. Similarly, the second portion **404'** can extend around the entire periacetabular area around the acetabulum **84** when additional stability and attachment area is desired for the particular patient or preferred by the surgeon. The bone engagement surface **408'** can be designed to match complementarily to portions of the acetabular rim surface **84**, of the acetabulum **82** and of an adjacent periacetabular area of the pelvis **80** of the patient for close contact/nesting thereon in only one position and orientation. The second portion **404'** of the acetabular alignment guide **400'** is also designed during the pre-operative plan to define a plurality of elongated through-slots, apertures or other guiding formations or holes **406'** directed toward the periacetabular area for guiding a plurality of alignment pins **420** parallel to the pre-determined acetabular centering axis **CC**, as discussed above in connection with FIGS. **5-7**. After the alignment pins **620** are secured to the bone, the acetabular guide **400'** can be removed leaving the alignment pins **420** for use with a reamer, as discussed below.

A reamer **331'** or **331''** can be guided by the alignments pins **420**, as shown in FIGS. **11B** and **12**, respectively, along the acetabular centering axis **CC**. An off-the-shelf or standard (non custom) reamer **331'**, **331''** can be used in combination with an adjustable or a patient-specific adapter **470'**, **470''**. The adapter **470'** can include one or more arms **474'** (two arms **474'** are illustrated in FIG. **11B**). Each arm **474'** can be coupled to a shaft **330'** of the reamer **431'** with a quick-coupling arrangement **474'**, which can be, for example, an opening in the arms configured for receiving the shaft **330'** or other coupler. Each arm **474'** can include at least one opening **478'** positioned and configured for receiving a corresponding alignment pin **420**, which is secured to the bone in a pre-determined position and orientation using the patient-specific alignment guide **400'** through a corresponding hole **406** of the guide **400''**. Accordingly, the location and orientation of the openings **478'** on the arms **474'** and relative to the acetabular

centering axis **CC** are patient-specific. In some embodiments, an arm **474'** can include more than one opening **478'**. The arms **474'** can be integrally attached to one another, or modularly or separately coupled to the shaft **330'**. One of the alignment pins, pin **420'** for example, can provide a fixed point of reference for measuring the length of the leg of the patient for determining the length of an implant **200'** and the depth in the corresponding intramedullary canal. The implant **200'** can include a head **203'** and a stem **201'**, as shown in FIG. **11C**. A scale or other measuring device **477** can be coupled to the pin **420'** for measuring the length and sizing the implant **200'**. The scale **477** can be slidably placed over the pin **477'** as shown in FIG. **11B**. The length can be measured before implantation and also-post implantation (as shown in FIG. **11B**) for confirming proper impaction and placement of the implant.

Referring to FIG. **12**, a non-custom reamer **331''** can be coupled with a patient-specific adapter **470''** designed to slide over the alignment pins **420**, after the alignment pins **420** are secured on the patient's pelvis **80** in a patient-specific configuration, position and orientation, which also determines the acetabular centering axis **CC**, as discussed above in connection with FIGS. **5-7**. In the embodiment illustrated in FIG. **12**, the adapter **470''** can be monolithic and include two arms **474''** for receiving respectively two alignment pins **420** through corresponding openings **478''**, although different number of arms **474''** can be used and each arm **474''** can include more than one opening **478''** for receiving more than one pin **420**. The adapter **470''** can be coupled to the reamer **331''** with a quick-connect to the shaft of the reamer **331''**, as described above in relation to FIGS. **4A-4G**, or with another type of connection **335''**, such as snap-fit or threadable socket or bayonet coupling. The reamer **331''** can be of the blade type, including reaming blades **333''**. In one embodiment, the blades **333''** can be removable, replaceable and/or disposable. Each blade **333''** can be semicircular or quarter-circular and can be attached to a chuck or other support **337''** of the reamer **331''** with set screws or grooves or jaws.

In some procedures, the acetabular implant **200** discussed above can be used to articulate with a patient-specific resurfacing or replacement proximal femoral component, as shown in FIGS. **13**, **14A** and **14B**. For example, a patient-specific resurfacing implant can be designed during the pre-operative plan based on image models reconstructed from scans of the patient.

Referring to FIG. **13**, when the femoral head **92** is salvageable and need not be resected and replaced, the diseased or defective surface of the femoral head **92** can be identified in the image. A femoral component **600** can be designed to replace the defective portions, such as poor bone quality and/or avascular regions of the femoral head **92**. The femoral component **600** can include a dome-shaped portion or dome **602** with an outer convex articulating surface **603** for articulating with an acetabular implant or the patient's natural acetabulum and an inner bone engagement surface **604** that is designed to match and be complementary and match the surface of the femoral head **92** with or without soft tissue attached, as determined in the pre-operative plan. The dome **602** can have a periphery **608** designed such that the dome covers and resurfaces all the defective portions of the femoral head **92**. The femoral component **600** can have a short stem **606**, which is inserted through the femoral head **92** and secured into the femoral neck **94**. The stem **606** can be designed during the preoperative plan based on the three-dimensional reconstruction of the patient's anatomy from the patient's scans such that the axis of the stem **D** is placed in a selected position and orientation relative to the neck **94** of the patient's and in a selected anteversion orientation relative to

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the proximal femur **90**. Additionally, the length of the stem **606** and the size and shape of the cross-section **607** along the length of the stem **606** can also be designed based on the preoperative plan and the reconstruction model of the neck **94** of the patient, such that bone preservation and adequate attachment support are balanced and/or optimized for the particular patient.

Referring to FIGS. **14A** and **14B**, a patient-specific femoral implant **618** for a proximal femur in which the femoral head **92** is resected can include a femoral head component **620**, a femoral neck component **624** and a femoral stem component **622**. The femoral implant **618** can be designed during the preoperative plan based on the three-dimensional reconstruction of the patient's anatomy from the patient's scans such that the femoral head implant **620** and femoral neck component **624** cooperate to retain the axis D and the center of rotation R of the patient's femur or acetabulum, based on surgeon determination and preference. The femoral neck component **624** can be designed to match the patient's femoral neck **94** in size and orientation. The femoral stem implant **622** can be selected from standard (non custom) stem sizes) or can be customized for length, cross-section and/or shape for the specific patient.

The foregoing discussion discloses and describes merely exemplary arrangements of the present teachings. Furthermore, the mixing and matching of features, elements and/or functions between various embodiments is expressly contemplated herein, so that one of ordinary skill in the art would appreciate from this disclosure that features, elements and/or functions of one embodiment may be incorporated into another embodiment as appropriate, unless described otherwise above. Moreover, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. One skilled in the art will readily recognize from such discussion, and from the accompanying drawings and claims, that various changes, modifications and variations can be made therein without departing from the spirit and scope of the present teachings as defined in the following claims.

What is claimed is:

1. An acetabular system comprising:
 - a patient-specific acetabular alignment guide including a bone engagement surface having first and second portions, the first portion configured and shaped to be conforming and complementary only to a portion of a rim surface around an acetabulum of a specific patient without extending into the acetabulum, and the second portion configured and shaped to be conforming and complementary to a periacetabular area outside the acetabulum of the specific patient in accordance with a three-dimensional model of the acetabulum of the specific patient reconstructed pre-operatively from an image scan of the patient, the acetabular alignment guide including a plurality of guiding formations extending through the second portion for guiding a plurality of alignment pins therethrough, wherein the plurality of guiding formations are arranged and configured based on a pre-operative plan for the patient.
2. The acetabular system of claim 1, further comprising a patient-specific alignment adapter couplable to an acetabular instrument, the alignment adapter including a plurality of apertures configured to correspond to the guiding formations of the acetabular alignment guide for sliding over the corresponding alignment pins.
3. The acetabular system of claim 2, wherein the plurality of guiding formations includes three guiding bores and the plurality of apertures of the patient-specific alignment adapter includes three corresponding apertures.

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4. The acetabular system of claim 2, wherein the guiding formations are parallel guiding bores.

5. The acetabular system of claim 4, further comprising an acetabular inserter, the acetabular inserter including a shaft passing through a snap-on side opening of the alignment adapter.

6. The acetabular system of claim 4, further comprising an acetabular inserter, the acetabular inserter including a shaft removably coupled to the alignment adapter and parallel to the guiding bores.

7. The acetabular system of claim 4, further comprising an acetabular impactor, the impactor including a shaft removably coupled to the alignment adapter and having a handle that is offset relative to a central portion of the shaft of the impactor.

8. The acetabular system of claim 4, wherein the patient-specific alignment adapter has a patient-specific surface and is slidable relative to the acetabular instrument.

9. An acetabular system comprising:

a patient specific acetabular alignment guide including a bone engagement surface configured and shaped to be conforming and complementary to an acetabular and periacetabular area of an acetabulum of a specific patient in accordance with a three-dimensional model of the acetabulum of the specific patient and based on a pre-operative plan, the acetabular alignment guide including a plurality of guiding formations extending therethrough for guiding a plurality of alignment pins in a periacetabular area of a patient;

an acetabular instrument including a handle, a shaft and an acetabular coupler; and

a first alignment adapter removably coupled to the shaft of the acetabular instrument, the first alignment adapter including a plurality of apertures configured to correspond to the guiding formations of the acetabular alignment guide, such that the alignment pins can pass through the apertures of the alignment adapter after the acetabular alignment guide is removed without removing the alignment pins from the patient.

10. The acetabular system of claim 9, wherein the shaft of the acetabular instrument is removably inserted through a coupling opening of the first alignment adapter.

11. The acetabular system of claim 10, wherein the coupling opening is a snap-on side opening.

12. The acetabular system of claim 9, further comprising a second acetabular instrument having a shaft removably couplable to the first alignment adapter.

13. The acetabular system of claim 9, further comprising: an acetabular impactor having a handle and a shaft offset from the handle; and

a second alignment adapter removably coupled to the shaft of the acetabular impactor, the second alignment adapter including a plurality of apertures complementary to the guiding formations of the acetabular alignment guide, such that the alignment pins can pass through the apertures of the second alignment adapter after the acetabular alignment guide is removed without removing the alignment pins from the patient.

14. The acetabular system of claim 13, wherein the shaft of the acetabular impactor is removably inserted through a coupling opening of the second alignment adapter.

15. The acetabular system of claim 14, wherein the coupling opening is a snap-on side opening.

16. The acetabular system of claim 14, wherein the impactor is modular.

17. The acetabular system of claim 9, further comprising an acetabular implant.

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 8,603,180 B2
APPLICATION NO. : 13/111007
DATED : December 10, 2013
INVENTOR(S) : John R. White et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title Page 9, References Cited, Other Publications, Column 2, line 51, (Information Disclosure Statement dated July 8, 2011, Form 1449, page 19, Non Patent Literature Documents, Reference No. CI2), Delete “Arthuroplasty” and insert --Arthroplasty--.

In the Specification

Column 3, Line 29; After “with”, delete “a”.

Column 6, Line 34; Delete “insert” and insert --inserter--.

Column 7, Line 39; Delete “insert” and insert --inserter--.

Column 7, Line 40; Delete “344” and insert --346--.

Column 7, Line 43; Delete “344” and insert --346--.

Column 7, Line 46; After “360”, delete “can include”.

Column 7, Line 53; After “shown”, insert --in--.

Column 7, Line 63; Delete “262” and insert --362--.

Column 8, Line 3; Delete “drier” and insert --driver--.

Column 9, Line 59; Delete “220” and insert --200--.

Column 10, Line 3; After “impactor”, delete “500a”.

Column 10, Line 8; After “second”, insert --shaft--.

Column 10, Line 38; Delete “406” and insert --478--.

Column 11, Line 13; After “reamer”, insert --,--.

Column 11, Line 34; Delete “84” and insert --82--.

Column 11, Line 47; Delete “620” and insert --420--.

Column 12, Line 12; Delete “477” and insert --420'--.

Column 12, Line 13; Delete “FIG. 11B” and insert --FIG. 11C--.

Column 12, Line 14; Delete “also-post implantation” and insert --also post-implantation--.

Column 12, Line 14; Delete “FIG. 11B” and insert --FIG. 11C--.

Column 13, Line 21; Delete “sizes)” and insert --sizes--.

Signed and Sealed this
Seventh Day of October, 2014



Michelle K. Lee
Deputy Director of the United States Patent and Trademark Office